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Food Security:
An Insurance Approach

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INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE
IFPRI

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FOREWORD

The International Food Policy Research Institute's early research efforts have shown dramatically what an immense food problem the Third World and the globe generally face over the next few decades. Solution to that problem requires a major commitment of resources and the political will to back up that commitment on the part of developing and developed countries alike. But, even if that commitment is made, it is becoming increasingly apparent that lack of purchasing power in the hands of the poor not only stands in the way of reaching the objective of adequate diets for all, but may also prevent latent demand from making itself felt through remunerative prices. Lacking the incentive of remunerative prices, production may not grow at the rates required to meet the true food needs of the world's population a decade or two from now, even though resources and technology are available to meet this objective.

That situation has prompted the Institute's research into policies for increasing incomes and food consumption of low income people through food subsidies, employment subsidies and market forces. It is of course the lower income majority who spend 50 or 60 percent of additions to their income on grain alone, as compared to the 5 or 10 percent of added income spent on grain by the upper income deciles. Therefore they are hurt more when supply variation forces prices up.

It has become apparent that for governments to make the political and economic commitments essential to increase effective demand for food by the lower income people, there must be a reasonable degree of certainty that this increased demand can be consistently met. Given the inevitable vagaries of weather and the variability of world prices, the high cost of national schemes of food storage and the intense demand for resources for development itself, it is essential that a viable international system of food security be devised. In response to this need, the International Food Policy Research Institute has carried on a research program dealing with various aspects of food security. This Research Report reflects part of this work. It suggests an approach based on insurance principles, by which the international community can contribute to the food security of food deficit developing countries without having to create large buffer stocks and stabilize world grain prices. The objective of such a scheme would be to permit developing countries to stabilize cereal consumption at a relatively stable cost.

The reserve proposal which is in the forefront of international discussion at the moment is that being considered by the International Wheat Council under the auspices of the United Nations Conference on Trade and Development. Whether countries can agree on a formula for a system of nationally held, internationally coordinated buffer stocks which would be operated in response to price movements remains to be seen. If no agreement is reached, the importance of considering a more limited approach to the food security problem of low income, food deficit developing countries is obvious. Even if agreement is reached, however, the food

security needs of many developing countries will still not be fully met.

Operation of an international reserve designed to deal with price instability in world markets does not eliminate the need for consumption adjustment in participating countries when prices exceed the release trigger. Developed countries with substantial livestock sectors can more easily make this adjustment than can developing countries in which a substantial portion of the population lives at the subsistence margin. Further, even if grain is released onto the market in years of relatively high prices, developing countries would still have to bid competitively with other importers to obtain needed supplies. In such years, developing countries with exceptionally poor harvests, foreign exchange constraints, and relatively small orders would be relatively weak bidders. Thus, in order to avoid curtailing consumption, they might still have no choice but to pay excessively high food import bills in relation to what their economies can afford. Finally, release of grain in response to price triggers would not take into account the fact that countries with less flexibility in making transport and handling arrangements for substantially increased imports would be at a disadvantage in obtaining access to this grain.

This report is part of an ongoing project of IFPRI's Trade Program, under the general direction of Alberto Valdes. Other aspects of this project include a quantitative assessment of the sources and magnitudes of food security in developing countries; the complementarity of grain reserves, food aid and food insurance; and a series of country studies assessing in detail the characteristics and magnitude of food insecurity and possibilities of implementing alternative approaches in Asia, Africa and Latin America.

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1

SUMMARY

This paper suggests an approach by which the international community can contribute to the food security of food deficit, developing countries without having to create large buffer stocks and stabilize world grain prices. The international community is considering an agreement which would establish minimum and maximum indicator prices for wheat, and use buffer stocks to defend them. But important differences among major participants about commodity coverage and the use of production adjustment and trade policy measures make agreement unlikely. A more acceptable alternative may be a scheme based on insurance principles specifically designed to assist food deficit, developing countries. The objective of such a scheme would be to permit developing countries to stabilize cereal consumption within a range of projected demand at a relatively stable cost.

Two alternative insurance schemes were evaluated for sixty-five food deficit, developing countries for the period 1978 to 1982: a purely compensatory financing mechanism, and a financing mechanism combined with a physical wheat reserve. In the latter case, stocks would be released only during very high-price years (price above \$200 per metric ton (MT) or \$5.45 per bushel of wheat) and only to countries experiencing a production shortfall of more than 5 percent during those years. On the basis of present market conditions it was assumed that a physical reserve could be acquired from this year's crop at the prevailing price. Reserve levels of 4, 8, 12, 16, and 20 million tons were considered.

Five years was considered a reasonable period for making realistic statistical estimates. An agreement could be negotiated for a five-year period, but the anticipated duration would have to be considerably longer for the scheme to operate effectively.

Compensation from the scheme would be permitted whenever a developing country's cereal import bill exceeded a specified percentage of the trend import bill (e.g., 110, 120, or 130 percent of trend). The consumption level defended by the scheme at a given year depends on a country's cereal production during that year. Thus, if its domestic production shortfall is more than 5 percent below trend, the country's actual bill would be calculated for the quantity of imports that would maintain 95 percent of projected demand. If the shortfall is between 95 and 100 percent of trend production, consumption would be maintained at the same percentage of projected demand. Finally, if production exceeded trend, consumption would be maintained at 100 percent of projected demand. These rules would ensure that each country could maintain a consumption level between 95 and 100 percent of projected demand in all years, depending on the performance of its own cereal production. However, consumption is not restricted to the guaranteed level. A country can maintain its own supplementary reserves and/or allocate additional foreign exchange to food imports if it wishes to support a higher consumption level.

Because of the sharp fluctuations in domestic production in many developing countries, there would be at least some countries

eligible for compensation each year. Once a country's domestic production for a given crop year was known and enough information was available to permit an estimate of the expected world market price, the probable cost of import requirements could be estimated. Funds could then be made available to eligible countries. Some mechanism would have to be devised to tie these funds to the purchase of the specified quantity of grains for food consumption. Since in most years the world price would not be high enough to trigger release of grain from the reserve, the assistance to eligible countries would be in the form of compensatory financing. The wheat reserve would be drawn upon when world market prices exceeded the release price, and would be used only to compensate for production shortfalls of 5 percent or more below trend production in those years. This released grain would be valued at the prevailing world price, and the amount subtracted from the total compensation for which each country is eligible. The remainder of the payments due to countries would be provided through compensatory financing. In the event that production shortfalls and/or price increases were so extreme that resources would be exhausted before meeting the requirements of all eligible countries, the consumption level defended by the scheme would be reduced for each country and the additional consumption adjustments necessary would be shared proportionately by all participating countries.

The scheme is least costly with a grain reserve of about 8 million tons; with a reserve of about 16 million tons the cost is equal to that of a scheme operating solely as a compensatory financing mechanism. However, the differences between total expected costs at various reserve levels are so slight that they have no practical significance as a measure for deciding which alternative is preferable. More important is the effect of the reserve on the distribution of the cost of the scheme: the larger the grain reserve held in the system, the lower the probability of very high cost. Consequently, for a given level of funding, the larger the grain reserve, the greater the probability of achieving the objectives of the scheme. In addition, a larger grain reserve provides a higher and more equitable probability over the years of covering production shortfalls of 5 percent or more below trend production during high-price years. For these reasons if a grain reserve was established in conjunction with a compensatory financing mechanism, 20 million tons of grain would be the suggested reserve level for developing countries.

In addition to these technical considerations, a scheme with both funds and stocks has the advantage of providing a supply guarantee to back up the financial insurance, and is likely to be preferred by potential developed country contributors. Without a physical reserve, the additional purchasing power acquired by developing countries could, in periods of particularly short supply, pressure developed countries to make politically unacceptable adjustments in their own domestic consumption or cause the scheme to fail because of the imposition of export controls. The physical reserve could also provide an outlet for surplus stocks which tend to accumulate in certain exporting countries.

Alternative insurance levels for a scheme with a 20 million ton wheat reserve were evaluated and their costs compared to those for a scheme involving a compensatory financing mechanism only. The financial capacity needed to attain a given probability that the scheme will achieve its objectives under various alternatives is also calculated. Two important findings are worth mentioning here. First, a given level of funds provides a higher probability that the scheme

will achieve its objectives when the scheme involves grain reserves in addition to compensatory financing. Second, the marginal funds needed to increase the probability of the scheme achieving its objectives are larger the higher the probability level.

It should be noted that for a given level of funding, higher insurance coverage implies a greater risk of depleting funds during the last years of the five-year period; therefore, benefits are unevenly distributed over time and among countries, favoring countries that happen to draw early during the five-year period. For this reason, for a given level of funds the insurance coverage should be set at a level that would imply a high probability for the scheme achieving its objectives over the five-year period. Assuming that for most countries concerned a cereal import bill up to 130 percent of trend during some years would not be a formidable obstacle in meeting their consumption targets, a fund of $3.7 billion would cover the expected cost of a food insurance scheme. * Such a level of funding would assure at least a 75 percent probability of the scheme achieving its objectives. Additional funding of about $2.4 billion would increase this probability to about 90 percent.

The share of each country's benefits from the system has also been estimated based on the expected total withdrawals for a given country and the expected total cost of the scheme for the five-year period. India receives more than 20 percent of the benefits, followed by Morocco, Mexico, and Turkey. Six or seven countries account for almost 50 percent of the cost of the system.

Crucial components in the success of any food security scheme are the source and management of funds needed for its operation. One option is a scheme self-financed by the member countries. For example, if India had to pay an equal annual premium for the next five years based on its expected withdrawals, the premium would range from about $206 million to about $245 million, depending on the level of insurance provided by the scheme. In practice, however, most low income countries could probably not afford to participate unless the scheme were subsidized by developed countries. Developed countries could make their contributions either bilaterally or through a multilateral mechanism. Ideally, developed country assistance would be most effective and desirable from the point of view of recipient countries if it was a collective contribution that would be paid through an agreed upon cost-sharing arrangement. Donor countries could subsidize the premium payments of low income countries or make concessional food aid available to lower the cost of imports for recipient countries and thereby help them meet their food security premiums. Alternatively, funding countries could simply agree on the level of financial commitment they were willing to undertake collectively, and a scheme could be designed accordingly.

Whether funded by a schedule of premium payments or by a schedule of donor country contributions, the scheme should be funded to cover at least its expected cost at a given insurance level. Borrowing might be necessary if its cost exceeds the amount of funds available.

Finally the scheme could be funded through the compensatory financing facility of the International Monetary Fund (IMF)

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* This figure also includes the cost of $1.1 billion needed for the operation of the 20 million ton grain reserve.

by including cereal import expenditures in the IMF's existing compensatory financing facility for commodity exports or by creating a new facility. Funding the scheme through the IMF may be the most desirable approach, both because the IMF could handle the necessary financing arrangements and because the bureaucracy needed to operate it already exists.

2

FOOD INSURANCE AS A MEANS OF ALLEVIATING FOOD INSECURITY

Much of the debate in recent years over how to attain food security has concentrated on the desirability of accumulating large buffer stocks with the objective of stabilizing the world price of grains.* A number of developed countries, both importers and exporters, advocate such an approach for reasons having to do with the operation of their domestic food and agricultural policies. For developing countries, price stability resulting from buffer stocks would mean moderation of the often wide fluctuations in foreign exchange expenditures required to purchase food imports. But developing countries would have no special advantage over other buyers in obtaining grains from the buffer stock in years of short supply. Moreover, even with grain price stabilization, a country will still have a food insecurity problem to the extent that its domestic production fluctuates.

Apart from the degree of food security provided, several problems are inherent in such an approach. Although discussions are continuing in the International Wheat Council, it is not clear that nations could agree on the size, location, price bands and administration of the buffer stocks that would form the backbone of a price stabilization scheme. There are important differences among major participants about what production adjustment and trade policy measures should be used if buffer stocks are not adequate to keep prices within the specified range. If a group of countries reached agreement on buffer stocks without inclusive participation, member countries would want to exclude non-member countries from the benefits of stable prices. In order to do this, members in the scheme would have to design some system of export controls or discriminatory pricing to bar non-members from reaping benefits from the partial buffer stocks. While it might be possible to bar non-members, such action would invite political or trade retaliation that could ultimately break the system.

Even if a group of nations could agree in principle on a price stabilizing arrangement, agreement on a cost-sharing formula would be difficult to work out. Although under certain assumptions one can infer which nations stand to gain the most from stable prices, it is not possible to estimate accurately the actual monetary costs and benefits. Moreover, a price stabilizing arrangement does not allow individual countries to select the degree of food security they desire and does not allow them to reduce their share in the cost. In some countries food production is highly variable; in others, it is relatively stable. In addition, some nations have enough foreign exchange to absorb variations in domestic production by buying grain in the international market. Therefore, the degree of food security desired will vary.

Finally, pursuit of short-run self-interest by grain exporters and importers thwarts the

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* A brief review of the literature on the welfare implications of price stabilization and the experimental work on grain buffer stocks is presented in Appendix 1.

negotiation and implementation of a price stabilization arrangement. During years of good harvests, when low grain prices and ample supplies encourage the initiation of a buffer stock system, importing nations see no urgent need for one, because they realize that major grain producing nations will unilaterally store excess supplies for release in years of short supply anyway. On the other hand, when poor harvests have forced grain prices up, exporting countries show little interest in buffer stocks that would set an upper limit on the international grain price.

This obstacle to grain stocks clearly would disappear if policy makers took longer-term considerations into account. However, the usually short planning horizon of governments and the political pressures of interest groups in both exporting and importing nations bias decisions toward immediate gains. As a result, proposals for grain buffer stocks face serious obstacles caused by the divergence of short-run interests between importing and exporting countries.

Description of the Insurance Approach

Guidelines and objectives

By limiting the scope of an agreement and specifically addressing the needs of food deficit, developing countries, the international community could avoid some of the problems associated with a full-scale market price stabilization agreement. One way would be to design an agreement along insurance principles.

Johnson* has proposed a food insurance scheme which calls for the United States and other industrial countries to cover production shortfalls in developing countries when cereal output drops below a given percentage of their production trends. Although specific to developing countries, this proposal treats only one of the two aspects of food insecurity.

The two sources of food insecurity in developing, food deficit countries are: (1) a temporary reduction in domestic food production and (2) a temporary increase in international foodgrain prices. The Johnson proposal deals only with the first source of food insecurity and implicitly assumes that food deficit, developing countries can overcome the second source by varying their foreign exchange expenditure on food imports. But even if such variable spending of scarce foreign exchange were possible, for many developing countries it could severely hamper overall economic development.† Therefore, to protect developing countries from both sources of food insecurity, a food security scheme must deal with fluctuations in their food import expenditures.

Reutlinger‡ has redefined food insecurity of developing countries by recognizing the importance of fluctuating foreign exchange requirements. His study estimates the cost of financing food imports needed to maintain consumption in developing countries when their food import bills exceed normal.

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* D. Gale Johnson, "Increased Stability of Grain Supplies in Developing Countries: Optimal Carry-overs and Insurance," World Development 4 (1976):977-987.

† Dale E. Hathaway, "Grain Stocks and Economic Stability: A Policy Perspective," in Analysis of Grain Reserves, a Proceedings. ERS-634. (Washington, D.C.: U.S. Department of Agriculture and the National Science Foundation, 1976).

‡ Shlomo Reutlinger, Food Insecurity: Magnitude and Remedies, World Bank Working Paper No. 267. (Washington, D.C.: World Bank, July, 1977).

This study follows Reutlinger's approach in principle, but adds a number of refinements. First, rather than treating developing countries as a group, this study estimates the level and variability of grain production and the import requirements of each country individually, taking production and consumption growth into account. Second, it clearly specifies operating rules at the country level, allowing an objective estimate of benefits received by each country. Finally, this study estimates the cost of an insurance scheme for a period of five consecutive years rather than for a single independent year.

The objectives of the food security scheme analyzed here, stated more explicitly, are: (1) to permit developing countries to stabilize food consumption within a range of projected food demand, and (2) to permit developing countries to stabilize their food import bill within a range of their trend import bill while stabilizing food consumption. Adjusted target consumption, the consumption level defended by the system, varies between 95 and 100 percent of the projected cereal demand for each country. Although a country's actual consumption levels might be higher or lower than adjusted target consumption, adjusted target consumption constitutes the basis for determining year-to-year transactions between a country and the system. *

In years of very high world prices and/or very low domestic production, a country could be eligible to draw from the system's resources in order to maintain its adjusted target consumption level. Withdrawals from the system depend on the variability of each country's cereal import bill and on the degree of insurance desired. † The system would make payments only for the amount by which a country's actual import bill exceeds a certain percentage of its trend cereal import bill. Should a country desire a high level of insurance, it could set this uninsured import bill level very low, and thus draw frequently from the system. This discussion assumes an uninsured level of 110 percent

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* Adjusted target consumption in the ith country during a particular year (C^*_{it}) is determined on the basis of actual grain production level in the country for that year. It is set lower than projected demand ($\overline{C}_{it}$) when a country experiences a production shortfall. Thus, if actual production for a particular year (Q_{it}) is below 95 percent of trend production ($\overline{Q}_{it}$), then

$$C^*_{it} = 0.95\ \overline{C}_{it}$$

If Q_{it} is between 95 percent and 100 percent of $\overline{Q}_{it}$, then C^*_{it} is set at the same level i.e.,

$$C^*_{it} = \frac{Q_{it}}{\overline{Q}_{it}}\ \overline{C}_{it}$$

and finally, if Q_{it} is above $\overline{Q}_{it}$, then $C^*_{it} = \overline{C}_{it}$. Appendix 2 describes the analytical expressions used in obtaining projected demand and trend production.

† Throughout this paper, the term cereal is used to refer to wheat, rice and feedgrains. The composition of cereal imports varies from country to country and even within countries, depending on consumption preferences, and the variability of the composition in its domestic cereal production. For purposes of this study, wheat is taken as the basic staple commodity, and the value of cereal imports is computed as if these imports were composed entirely of wheat. The term grain is used in the context of discussions of physical reserves which could be comprised either of wheat only or of wheat and rice. The grain reserve discussed in this paper is assumed to be wheat.

for all countries. * In other words, if a country's target food imports in a given year (computed as adjusted target consumption minus current production), valued at the current world price, exceeded 110 percent of its trend import bill, † then the country is eligible for compensation from the system for the excess bill over 110 percent of trend.

Reducing the consumption level that the system defends when domestic production falls below trend production provides a country with incentives to maintain production at least at its trend level. If the system provided coverage for 100 percent of each country's projected demand, then there would be no means of preventing a country from drawing excessive short-term benefits by deliberately under-reporting domestic production and/or reducing resources allocated to food production. ‡

Over time, under-reporting would result in a decrease in the rate of growth of domestic production, and would thus lead to an increase in trend imports. Because the system compensates a country based on the difference between its actual import bill and a percentage of its trend import bill, an increase in trend imports caused by under-reporting would reduce the compensation for which the country qualifies.

An international food insurance scheme that would provide member countries the resources to defend their consumption can operate in either of two ways: (1) the scheme can serve as a purely financial mechanism that provides member countries with funds to cover overruns in their cereal import bill; or (2) the insurance scheme can operate a limited size grain reserve in addition to the financial mechanism; grain would be released to eligible member countries when world food supplies are very short. Both of these alternatives will be examined.

A Food Insurance Scheme as a Compensatory Financing Mechanism

A food insurance scheme operating as a purely financial compensatory mechanism implies that the system provides member countries with the funds necessary to cover overruns in their cereal import bill. Recipient countries use these funds to import food

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* Two alternative levels of 120 and 130 percent are also evaluated.

† Trend import bill equals the product of trend imports (projected demand minus trend production) and the average world price.

‡ There is another reason for not providing 100 percent coverage: the primary source of income in most of the developing countries is agricultural production. Thus a high correlation exists between rural income levels and grain production. This correlation implies that in years of low grain production, effective demand for grain is below projected demand (based on a smooth normal growth in domestic income). Therefore, aside from providing proper disincentives to countries in cases of below-trend food production, an additional reason for setting adjusted target consumption below projected demand is due to an actual reduction in effective demand because of income losses in part of the population.

It can be argued that the purpose of a food security system should be to prevent such a reduction in effective demand, particularly among the rural poor, who are most likely to suffer nutritionally from the reduction in consumption. However, making available food supplies in excess of those implied by effective demand could have undesirable consequences unless governments are willing to make appropriate adjustments in their internal food distribution system in favor of the poor majority (including creation of domestic reserves to supplement this scheme). If such measures exist, and the resources of the food security scheme permit, the minimum target consumption level to be defended by the scheme could be set at higher than 95 percent of trend consumption. In these ways it should be possible to minimize, if not eliminate, the hardships caused by domestic production shortfalls.

to meet their consumption targets.

Table 1 presents several possible transactions between a hypothetical country and the system. In year 1, actual production in the country in question is 90 percent of trend. Thus the rules of the system set adjusted target consumption at 95 percent of projected demand or 10.45 million metric tons. The difference between adjusted target consumption and actual production, multiplied by the current world price, yields the size of the target import bill. Because the target import bill for year 1 ($137.8 million) is less than 110 percent of the trend import bill ($165 million), the country receives no compensation from the system. In year 2, actual production is 98.06 percent of trend and adjusted target consumption is set at 11.18 million metric tons (i.e., 98.06 percent of projected demand). With the target import bill smaller than 110 percent of trend, the country again receives no compensation in year 2. In the third year, actual production exceeds trend, so adjusted target consumption equals projected demand. The combinaticn of a good domestic crop and a low world price during this year results in a target import bill considerably lower than the trend import bill. The country is again ineligible for compensation from the system. In year 4, low domestic production and high world price result in a much higher import bill. The target import bill equals $395.0 million, considerably more than 110 percent of trend import bill (which is equal to $214.5 million). Thus, the country is eligible for compensation in the amount of $180.5 million ($395.0 million minus $214.5 million). Finally, in year 5, although the country has a better than average crop of its own, a continued high world price results in an import bill that still exceeds 110 percent of trend import bill. Thus, the country receives compensation in the amount of $3 million.

A Food Insurance Scheme as a Combined Grain Reserve and Compensatory Financing Mechanism

Thus far the discussion described the operation of a food insurance scheme as a compensatory financing mechanism only. A system that used a grain reserve in conjunction with a compensatory financing mechanism might provide a more cost-effective way of achieving the same objectives. Moreover, the presence of a grain reserve adds an important supply guarantee to the system. In high price years commercial stocks are ordinarily very low or nearly depleted, so that merely providing financing in these years cannot guarantee availability of supplies. In fact, compensatory payments may bring only higher prices and greater financial strain on food importing countries as buyers bid for scarce supplies on the world market. Exporting countries may also prefer a system with a grain reserve, since the reserve would protect them against consumption adjustments or the need to impose export controls during high-price years. Appropriately managed, a relatively small reserve could help to guarantee supplies and conceivably reduce the cost of the system while minimizing the disruptive effects on the international grain market.

A food security system with a limited reserve would have to specify price levels at which it would acquire and release grain. The correct choice of these price levels is crucial to the system's success. On the one hand, a low acquisition price and a high release price mean less interference with the world grain market. On the other hand, there should be a reasonable probability that the world price will trigger acquisition and release sometime during the period for which an international insurance scheme is

Table 1— How a food insurance scheme operates as a compensatory financing mechanism for a hypothetical country during a five-year period

	Year 1	Year 2	Year 3	Year 4	Year 5
Current world price of wheat ($/MT) a/	95.0	140.0	110.0	250.0	180.0
Cereal production trend (million MT)	10.0	10.3	10.7	11.2	11.7
Projected cereal demand (million MT)	11.0	11.4	11.9	12.5	13.1
Trend cereal imports (million MT) b/	1.0	1.1	1.2	1.3	1.4
Trend cereal import bill (million $) c/	150.0	165.0	180.0	195.0	210.0
110 percent of trend import bill (million $)	165.0	181.5	198.0	214.5	231.0
Actual cereal production (million MT)	9.0	10.1	11.0	10.3	11.8
Actual production as percentage of trend production (%) d/	90.0	98.0	102.8	92.0	100.9
Adjusted target consumption (million MT) e/	10.45	11.18	11.90	11.88	13.1
Target cereal imports (million MT) f/	1.45	1.08	0.9	1.58	1.3
Bill for target imports (million $) g/	137.8	151.2	99.0	395.0	234.0
Compensation to country (million $) h/	0.0	0.0	0.0	180.5	3.0

a/ For this illustration only, assume that the average world price of wheat equals $150/metric ton.

b/ Computed as the difference between row 3 and row 2.

c/ Computed as the product of row 4 and the assumed average world price of wheat ($150/metric ton).

d/ Computed as the ratio between row 7 and row 2.

e/ Computed by adjusting projected demand (row 3) on the basis of the values of row 8 as explained in the text.

f/ Computed as the difference between row 9 and row 7.

g/ Computed as the product of row 10 and row 1.

h/ Computed as the difference between row 11 and row 6 when the former is larger than the latter.

negotiated.

If, for example, a food insurance scheme has an initial projected life of five years, a release price reached in only one year out of thirty would be unrealistic, since there would be a very low probability that the system would use its grain reserve. Conversely, a release price that is reached in two years out of four would interfere unnecessarily with the free market. With these considerations in mind, a release price level which will be exceeded in one year out of five and an acquisition price which will be exceeded in four years out of five have been assumed. Given the world price distribution for wheat (see Appendix 3), an acquisition price of $105 per metric ton (about 80 percent probability of being exceeded) and a release price of $200 per metric ton (about 20 percent probability of being exceeded) are specified.* Using these prices, the system could expect to acquire grain in one year out of five and to release it in one year out of five.

Once the world price reaches the release price, production levels in member countries will determine which ones are eligible for compensation in the form of grain. When high prices trigger the grain release mechanism, countries whose production falls short of trend by more than 5 percent are eligible to bring their grain supplies up to 95 percent of trend by drawing upon the system's reserves, to the extent that such reserves are available.†

Thus, consider again the hypothetical country illustrated in Table 1. During year 4, the high-price year, domestic production in the country in question is 92 percent of trend production, so the country is eligible to draw from the grain reserve facility of the system. The 95 percent level of trend production equals 10.64 million metric tons, so the country receives 0.34 million metric tons (10.64 minus 10.30) of grain.‡ Use of the reserves reduces the compensatory financing received by the country in question for that year by the value of the grain released to it, (i.e., by $85 million [0.34 x 250]). The country receives the remaining $95.5 million (180.5 minus 85) in compensatory funds.

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* The effect of an alternative release price of $170/metric ton is also analyzed. The probability that world price would exceed this level in a given year is about 32 percent.

† An alternative level of this country-specific trigger for grain release is also considered. In this case, grain is released to countries that experience a production shortfall greater than 3 percent during high price years and in amounts (to the extent available in the system) that will bring the physical availability of grain in the country to 97 percent of trend production.

‡ If the grain available in the grain reserve facility of the system is not enough to cover all requests, then each country's allotment is reduced in proportion to the available reserve.

3

ESTIMATION OF THE COST AND DISTRIBUTION OF BENEFITS OF THE PROPOSED FOOD INSURANCE SCHEME

Components of the Simulation Model Used in the Evaluation of the Proposed Food Insurance Scheme

To evaluate the proposed scheme a model was built which simulates projected demand, trend production and production variability on a country by country basis, as well as the variability of the world price of wheat.

A country's projected cereal demand is obtained on the basis of past per capita cereal consumption and projections of population growth, GNP growth, and income elasticities of demand. Appendix 2 describes the analytical expression used and the data on which demand projections are based.

Analysis of each country's past production provides cereal production trends and production variability. Trend production is based on a logarithmic time trend derived from data on total cereal production for the period 1960 to 1975. Past variability of production above and below trend is estimated, and cross-country correlation in production is also analyzed. Appendix 2 presents the methodology used and results obtained from this analysis.

Cereal import trends and the variability of imports by country are derived by subtracting simulated future production outcomes from projected demand. Table 2 presents aggregate figures for projected demand, trend production, trend imports and variability of imports. Aggregate projected demand of food deficit, developing countries grows by about 3.3 percent annually, whereas domestic grain production grows by about 2.9 percent annually. As a result, aggregate trend import requirements will grow from about 42.0 million metric tons in 1978 to about 52.4 in 1982.

Production and consequently, import requirements fluctuate around trends, and due to the assumed multiplicative nature of production variability (see Appendix 2), the absolute size of fluctuations increases over time. Thus, the standard deviation of production increases from 9.6 million metric tons in 1978 to about 10.6 million metric tons in 1982. On the basis of these standard deviations of production, a range in the variability of import requirements can be computed (see Table 2).

Growth and variability of cereal production vary greatly from country to country, as shown in Table 17, Appendix 2. In addition, though percentage deviations from grain production for the countries considered in aggregate are rather low (standard deviation of about 3 percent), percentage deviations on an individual country basis are much greater. Cereal production variability expressed as a percentage of trend is highest in North Africa and the Near East and lowest in Southeast Asia. However, Southeast Asia's production variability in absolute levels is much greater because its production level is much higher.

The world wheat price generating function is presented in detail in Appendix 3. Analysis of past correlation between total developing countries' cereal imports and world wheat price reveals the causal effect

Table 2—Aggregate projected demand, trend production, trend imports and import variability of food deficit, developing countries, 1978–1982 a/

	Projected Demand b/	Trend Production c/	Trend Imports d/	Standard Deviation of Production and Imports e/	95% Confidence Interval for Domestic Production f/		95% Confidence Interval for Imports	
	(million metric tons)							
1978	352.0	310.0	42.0	9.6	291.2	328.8	23.2	60.8
1979	363.5	319.9	43.6	9.8	300.7	339.1	24.4	62.8
1980	375.2	328.7	46.4	10.0	309.1	348.3	26.8	66.0
1981	388.3	338.8	50.0	10.3	318.6	359.0	29.8	70.2
1982	401.5	349.1	52.4	10.6	328.9	369.3	31.6	73.2

a/ See Appendix 2 for countries included.

b/ Computed from individual country projected demand as described in Appendix 2.

c/ Computed from individual country trend production as described in Appendix 2.

d/ Computed as the difference between projected demand and trend production.

e/ Since imports are computed as a difference between projected demand and randomly generated production, and there is no variability in projected demand, the standard deviation of production equals the standard deviation of imports.

f/ Range of values within which actual production will fall 95 percent of the time.

of these imports on world price and the price generating function incorporates this effect. The serial correlation observed in time series price data is also taken into consideration by incorporating a lagged price into the price generating function. All other factors that have an impact on world wheat price formation are treated as a random variable. The probability distribution obtained for world wheat price is depicted in Table 19, Appendix 3. The resulting expected price equals $155.8 per metric ton.

Estimated Cost and Distribution of Benefits of the Scheme Operating as a Compensatory Financing Mechanism

A food insurance scheme operating as a compensatory financing mechanism would provide member countries the foreign exchange needed to defend their adjusted target consumption when their import bills for that level of consumption are excessive.

The simulation model generates 300 five-year (1978 to 1982) cereal production sequences for each member country, and 300 corresponding five-year world wheat price sequences. As explained earlier, the cereal import requirement for a given year is computed as the difference between adjusted target consumption and the production level randomly generated by the model. The cereal import requirement, multiplied by the corresponding world price for that year, provides the target cereal import bill for the country in question. This import bill is then compared with the country's trend cereal import bill.* When its target cereal import bill is above the uninsured level (e.g., 110 percent of trend import bill), the country receives compensation from the system for the amount of the excess.

The summation of all payments to member countries for a given year constitutes the cost of the scheme for that year. The cost of the scheme for a five-year sequence is expressed in present value by discounting future expenditures.† The outcomes of all 300 sequences are summarized by probability distributions.

Table 3 presents the probabilities of different costs of operating the scheme. For example, the probability that the total cost of the scheme for the five-year period will be $3 billion or less is 53.8 percent. Similarly, there is a probability of about 95 percent that the total cost will be less than $16 billion. The expected cost of the scheme represents the mean of the present values of the costs generated for the 300 five-year sequences. This expected cost for the five-year period equals $5.1 billion. Because the cost distribution is rather skewed, (median cost less than $3 billion) the probability that the cost of the scheme will exceed the expected cost of $5.1 billion is about 30 percent. In other words, if the scheme were to be set up with a financial capacity equal to its expected cost of $5.1 billion, this amount would provide about a 70 percent guarantee of meeting all needs for the entire five-year period. Higher degrees of assurance would require substantially more funds. For example, a 95 percent guarantee would require about $16 billion.

One important qualification should be

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* The trend cereal import bill is computed as the difference between projected demand and trend production for a given year, multiplied by the expected world wheat price ($155.8/metric ton).

† A discount rate of 8 percent per annum is assumed here. Alternative discount rates are also analyzed in a later section of this paper.

Table 3—Probability distribution of the total cost of the scheme operating as a compensatory financing mechanism for the five-year period, 1978 to 1982

Present Value of Total Cost a/ ($ billion)	Relative Frequency b/ (%)	Cumulative Frequency c/ (%)
0–1	20.0	20.0
1–2	21.8	41.8
2–3	12.0	53.8
3–4	7.7	61.5
4–5	8.0	69.5
5–6	5.0	74.5
6–7	4.8	79.3
7–8	2.2	81.5
8–9	2.1	83.6
9–10	3.3	86.9
10–11	1.5	88.4
11–12	1.4	89.8
12–13	1.5	91.3
13–14	1.4	92.7
14–15	0.4	93.1
15–16	1.1	94.2
16–17	1.1	95.3
17–18	1.1	96.4
greater than 18	3.6	. . .

a/ The expected present value of the cost equals $5.1 billion. A discount rate of 8 percent has been assumed here. The system is assumed to cover the excess over 110 percent of trend in each country's current cereal import bill.

b/ The relative frequency of a cost range is the probability that the scheme's total cost will fall in that range.

c/ The cumulative frequency of a cost range is the probability that the scheme's total cost will fall in or below that range.

made here. The cost figures presented in Table 3 represent the total cost of the scheme for the five-year period. Yearly costs are much lower. For example, the distribution of the cost of the scheme for the middle year (1980) is presented in Table 4. The figures in this table indicate that there is approximately a 95 percent probability that the cost of the scheme in 1980 will be $5 billion or less. The expected cost for that year is $1.2 billion.

An alternative way of expressing the yearly cost of the scheme is in the form of an average annual cost. The average annual cost represents an equal annual expenditure in each of the scheme's five years that would yield a present value equal to the expected cost. An average annual cost of $1.183 billion yields a present value of $5.1 billion as the scheme's expected cost.

Another important dimension of the annual cost of the scheme is how this cost grows over time. As shown in Table 2, the standard deviation of cereal import requirements increases in absolute terms with time, because a given percentage variability applied to increased total production yields greater absolute variations in output and in import requirement. In addition, the price distribution also becomes more disperse with time, reaching its equilibrium distribution by 1981, as the impact of the initial price on the world price generating function is minimized (see Appendix 3). Although both of these factors are responsible for an increase in the current cost of the scheme from $912 million in 1978 to $1,445 million in 1982, only about $332 million of the increase (about $83 million a year) is attributed to the increasing variability of cereal import requirements.

Obviously, the benefits from the operation of the scheme are not distributed equally among member countries. In general, the larger and more variable the domestic production of a country, the more it benefits from the scheme. Each country's share of total benefit has been computed (Table 5) by dividing the expected present value of payments received by the country by the expected present value of the total cost of the scheme. The figures of this table are rather interesting. India alone receives more than one-fifth of the total payments made by the system. Only seven countries—India, Morocco, Mexico, Turkey, Republic of Korea, Arab Republic of Egypt, and Nigeria—account for more than 50 percent of the total payments made by the system, and 20 countries account for about 80 percent.

India's very large share of expected benefits suggests that India might also be largely responsible for the skewed distribution of the total cost of the scheme (Tables 3 and 4). It is therefore of interest to investigate the cost of the scheme when India does not participate. This analysis is presented in Table 20, Appendix 4. As anticipated, the expected cost of the scheme is reduced from the $5.1 billion of Table 3 about 20 percent, a reduction equal to India's share. More important, the cost distribution has become considerably less skewed. For example, the probability that the present value of the total cost of the scheme will exceed $12 billion is only 6.5 percent, compared to about 10 percent when India is included. Table 21, Appendix 4 presents the distribution of current cost of the scheme for 1980, the middle year of the five-year period, without India. Again, one can observe an expected cost about 20 percent lower than that expressed in Table 4 and a much less skewed distribution of payments.

Table 4—Probability distribution of current cost of the scheme operating as a compensatory financing mechanism for the middle year (1980) of the five-year period

Cost [a/] ($ billion)	Relative Frequency (%)	Cumulative Frequency (%)
0–1	69.5	69.5
1–2	11.6	81.1
2–3	6.2	87.3
3–4	4.4	91.7
4–5	3.6	95.3
5–6	1.1	96.4
6–7	1.1	97.5
7–8	0.7	98.2
8–9	0.0	98.2
9–10	0.4	98.6
10–11	0.7	99.3
greater than 11	0.7	. . .

a/ The expected current cost equals $1.2 billion. The excess over 110 percent of trend in each country's current cereal import bill is covered by the scheme.

Table 5—Estimated percentage share of benefits from the scheme operating as a compensatory financing mechanism [a/]

Country	Percentage Share of Benefits	Country	Percentage Share of Benefits	Country	Percentage Share of Benefits
1. India	20.80	17. Sudan	1.79	33. Senegal	.61
2. Morocco	7.76	18. Peru	1.75	34. Jordan	.55
3. Mexico	5.02	19. Zambia	1.75	35. Ecuador	.38
4. Turkey	4.24	20. Tunisia	1.71	36. Bolivia	.37
5. Korea, Rep. of	4.23	21. Sri Lanka	1.63	37. Zaire	.37
6. Egypt, Arab Rep. of	4.08	22. Chile	1.44	38. Cameroon	.36
7. Nigeria	4.01	23. Philippines	1.19	39. Jamaica	.36
8. Indonesia	3.63	24. Burma	.98	40. Dominican Rep.	.36
9. Bangladesh	3.17	25. Lebanon	.84	41. Cyprus	.34
10. Syrian Arab Rep.	3.13	26. Tanzania	.81	42. Yemen Arab Rep.	.31
11. Algeria	2.92	27. Malaysia	.80	43. Mali	.30
12. Iran	2.77	28. Malawi	.80	44. Malagasy	.30
13. Brazil	2.41	29. Libya	.70	45. Niger	.28
14. Venezuela	1.99	30. Afghanistan	.67	46. Ivory Coast	.27
15. Cuba	1.94	31. Colombia	.66	47. Trinidad	.25
16. Iraq	1.84	32. Upper Volta	.64	48. El Salvador	.24

Table 5—Continued

Country	Percentage Share of Benefits	Country	Percentage Share of Benefits	Country	Percentage Share of Benefits
49. Angola	.23	55. Paraguay	.16	61. Liberia	.08
50. Ghana	.23	56. Guatemala	.16	62. Sierra Leone	.08
51. Uganda	.22	57. Panama	.14	63. Benin	.06
52. Costa Rica	.20	58. Haiti	.11	64. Gambia	.02
53. Nicaragua	.17	59. Guinea	.11	65. Chad	.02
54. Honduras	.16	60. Rwanda	.09		

a/ Computed by dividing the expected present value of payments received by a country by the expected present value of the total cost of the scheme and multiplying by 100.

Estimated Cost and Distribution of Benefits of the Scheme Operating as a Combination of Grain Reserves and Compensatory Financing

The objective of the food security scheme can be achieved, alternatively, by a system using a grain reserve in conjunction with a compensatory financing mechanism. As discussed earlier, the system would accumulate grain when the world price fell below $105 per metric ton. When the world price rose above $200 per metric ton, the system would release grain to countries that experienced a shortfall of more than 5 percent below trend production for that year.

To realistically analyze the system with grain reserves, the present situation in the world grain market should be taken into consideration. Current wheat prices are below the system's acquisition price level and supplies are ample. Thus, immediately after being set up the system could acquire the desired grain reserve. With an initial expected life of five years for the scheme it would then be unnecessary to make another acquisition of grain when part of the initially acquired grain is drawn or the stock is depleted. If additional grain were acquired, it is highly unlikely that it would be drawn upon in the remainder of the five-year period. Given the world price distribution, the probability of price fluctuating from low to high twice within the five-year period is almost zero.

Therefore, the cost evaluation of this scheme assumes a one-time grain acquisition at the beginning of the five-year period. This grain is acquired at the current world wheat price, stored on behalf of the scheme at certain agreed upon localities at a certain annual storage rent, and released for the use of member countries in years when price exceeds $200 per metric ton. *

The cost of this scheme is again estimated by simulation analysis. The scheme operates exactly as described in the previous section when world wheat prices are below $200 per metric ton. When the world wheat price is above $200 per metric ton, the system makes part of the compensation to eligible countries by releasing grain (to the extent available) in order to bring the physical availability of grain in eligible countries up to 95 percent of trend production. The released grain is valued at the prevailing world wheat price of that year, and the value of the grain is subtracted from the monetary amount for which each country is eligible. After grain transactions have taken place, compensatory financing is made available for the residual. The total compensation paid to countries eligible for grain during a high-price year is monetarily equivalent to that of the scheme that provides compensatory financing only.

In addition to the cost of the compensatory financing mechanism, there are three other cost components which have to be taken into account in computing the total cost of this system. First, the acquisition cost at the beginning of the period; it is assumed that grain is bought at $90 per metric ton, which was approximately the world wheat price in October 1977. Second, the carrying charge for the grain stored on behalf of the scheme is assumed to equal

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* If the stock is depleted during this five-year period, and if the prospects of renegotiating a new agreement at the end of this period are good, then the authorities of this scheme could replace the depleted grain during the next low-price year to provide continuity for the new agreement. This complication was thought unnecessary for the purpose of this analysis.

$10 per metric ton annually. * Finally, the salvage value of the grain remaining in the system at the end of its projected five-year life has to be subtracted from the system's cost. The salvage value of this residual grain is assumed to equal the residual quantity multiplied by the market price prevailing in the final year.

Again, the present value calculated by discounting future expenditures and revenues expresses the cost of the scheme for the five-year period of its operation. Five grain reserve levels have been analyzed and associated costs are presented in Table 6. The existence of a grain reserve in the system has some effect on the total cost of the scheme. For example, compared with the scheme that provides only financing, a grain reserve of 8 million metric tons reduces the expected present value of the cost of the system by about $59 million, while a grain reserve of 20 million metric tons increases the cost of the system by $47 million.

Figure 1 depicts the effect on costs of various levels of grain held by the system. One can observe that there are decreasing marginal savings to the compensatory financing mechanism as the size of the grain reserve increases. The first 4 million metric tons of grain result in a reduction in the cost of compensatory financing of $319 million; the second 4 million metric tons have a smaller effect, $280 million. The last increment (from 16 to 20 million metric tons) decreases the compensatory financing cost of the system by only $118 million. Marginal savings exceed marginal costs up to a grain reserve level of about 8 million metric tons. Thus, a level of about 8 million metric tons of grain is the most cost effective. Also, from Figure 1 it can be observed that a scheme with a grain reserve of about 16.5 million metric tons is equal in cost to a scheme operating as a purely compensatory financing mechanism.

The striking finding from this analysis is that the total costs of operating the system at various grain reserve levels are not significantly different.† Thus, criteria other than expected cost should determine the choice of the appropriate size of the grain reserve, if any. One such criterion is how well the presence of grain in the system raises the physical availability of grain in every member country to 95 percent of trend production during very high-price years. Table 7 shows how different reserve levels fulfill the objective of attaining supplies equal to 95 percent of trend during high-price years. For example, a reserve level of 8 million metric tons implies that there is a 77.5 percent probability that every member country attains the objective during the first year of operation. By 1982, this probability falls to about 19.5 percent. A reserve level of 20 million metric tons provides much greater

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* This figure is based on what the United States Department of Agriculture (USDA) pays United States grain producers to cover their storage cost for farmer-held stocks. Currently the USDA is required to pay producers twenty cents/bushel/year which will be raised to twenty-five cents/bushel/year in order to assure full implementation of the grain reserve program. Twenty-five cents/bushel/year translates into about $9.25/metric ton/year. The actual storage cost of the grain reserve to be held by the food security system proposed here will be a function of the location of these stocks, the existence of underutilized capacity, etc., factors which cannot be assessed at this stage. For this reason a sensitivity analysis is performed in a later section on the cost of this scheme under alternative storage costs.

† The cost reduction of a system operating with 8 million metric tons of grain versus a system without a grain reserve expressed as a percentage of the total cost is only 1.16 percent, very insignificant. Similarly, the cost increase of a system operating with 20 million metric tons of grain versus a system without a grain reserve expressed as a percentage of total cost is only 0.9 percent, again very insignificant.

Table 6—Expected present value of the total cost of the scheme operating with and without a grain reserve for the five-year period 1978-82 [a/]

Grain Reserve Level (million MT)	0 [c/]	4	8	12	16	20
Cost Components [b/] (million dollars)						
Cost of compensatory financing	5,108	4,789	4,509	4,290	4,124	4,006
Cost of grain reserve						
Acquisition cost [d/]	0	360	720	1,080	1,440	1,800
Carrying cost [e/]	0	124	287	444	608	775
Salvage value [f/]	0	222	467	752	1,073	1,426
Total	0	262	540	772	975	1,149
Total cost of the system	5,108	5,051	5,049	5,062	5,099	5,155

Note: The current cereal import bill in excess of 110 percent of trend is covered for each country.

a/ The compensations are in the form of funds when the world wheat price is below $200/metric ton. When the world wheat price exceeds $200/metric ton, part of the compensations are in the form of grain valued at the world price. The grain is released to countries that experience greater than 5 percent production shortfalls and in amounts (to the extent available) to bring physical availability of grain for every country to 95 percent of trend production.

b/ In computing present values a discount rate of 8 percent has been assumed.

c/ This corresponds to a system operating as a compensatory financing mechanism only.

d/ An acquisition price of $90/metric ton has been assumed.

e/ The carrying cost was calculated on the basis of a variable rental cost for storage facilities of $10/metric ton per year.

f/ The salvage value of the residual grain in the system at the end of the five-year period was based on the prevailing market price for that year.

Figure 1--Expected present value of the cost of a scheme operating as a combination of grain reserves and a compensatory financing mechanism

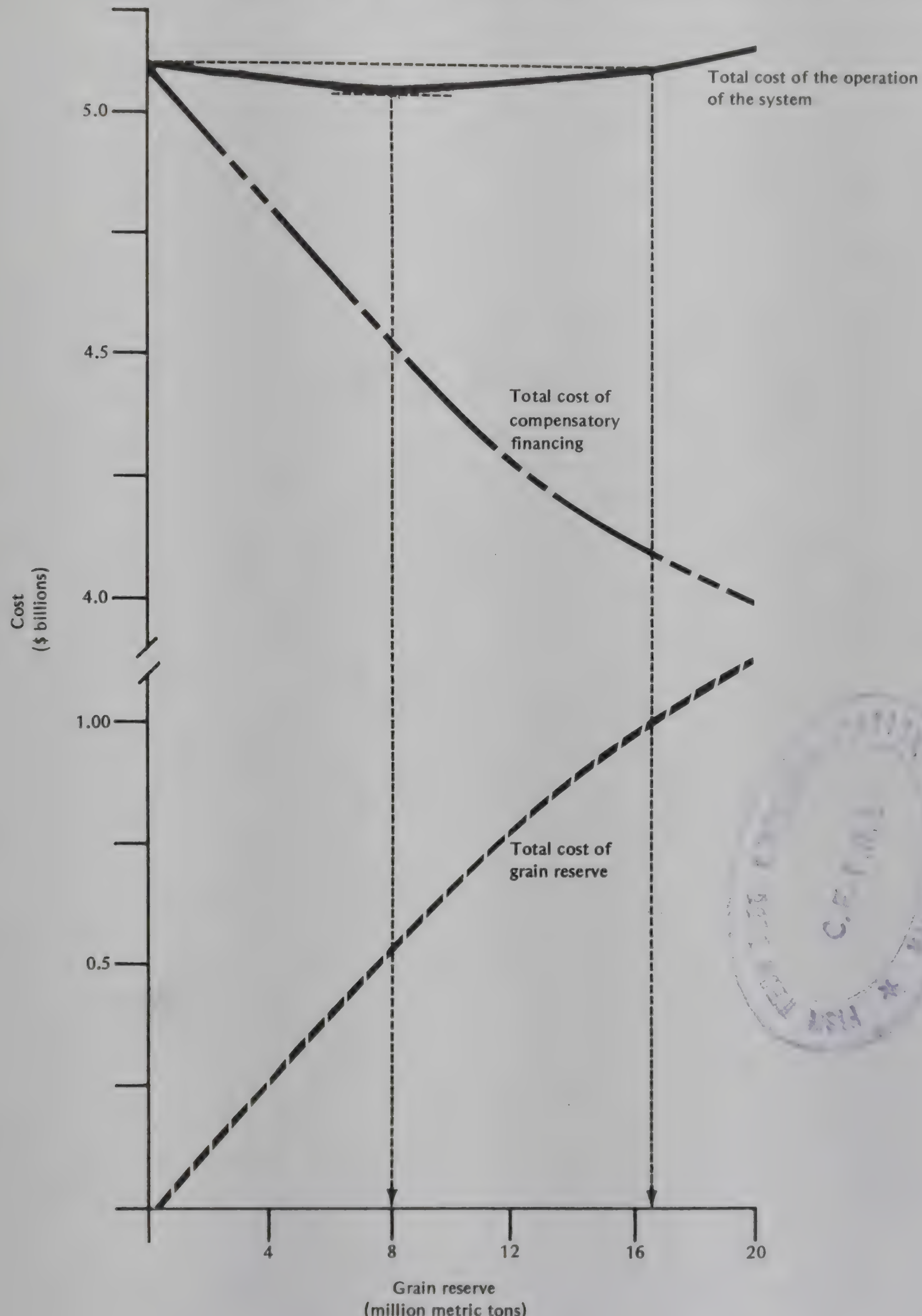

Table 7—Probability that varying grain reserve levels of the scheme will cover production shortfalls, during high-price years and expected grain required and released, 1978-82 a/

	Probability of Covering Production Shortfalls					Probability of Overall Grain Reserve Availability	Total Five Year	
Grain Reserve Levels	1978	1979	1980	1981	1982		Expected Requirements	Expected Release
(million metric tons)			(percent)			(percent)	(million metric tons)	
4	47.0	31.2	23.7	17.1	9.5	24.6	6.26	1.54
8	77.5	62.5	47.6	32.8	19.5	46.0	6.26	2.88
12	91.6	82.1	68.7	46.5	32.9	63.3	6.26	3.90
16	96.3	92.8	85.0	60.0	47.1	74.3	6.26	4.65
20	98.5	95.8	93.3	70.8	62.5	82.7	6.26	5.18

a/ The compensations are in the form of funds when the world wheat price is below $200 per metric ton. When the world wheat price exceeds $200 per metric ton, part of the compensations are in the form of grain valued at the world price. The grain is released to countries that experience greater than 5 percent production shortfalls and in amounts (to the extent available) to bring the physical availability of grain in all countries to 95 percent of trend production.

guarantees, satisfying this objective with a probability of 98.5 percent in 1978 and 62.5 percent in 1982.

This analysis suggests that a reserve level of 20 million metric tons provides high probabilities of supply guarantees for food deficit, developing countries during high-price years. Should greater guarantees be desired or should supply guarantees be set at different levels for different countries, the model could provide the grain reserve level required to meet these alternative objectives.

As expected, the larger the grain reserve held, the lower the cost of the compensatory financing component of the scheme. Thus, a system with 20 million metric tons of grain results in an expected present value of $4.0 billion for the compensatory financing component, $1.1 billion less than the present value of the scheme operating solely as a compensatory financing mechanism. In addition, the distribution of this cost becomes less skewed, meaning that extremely high compensatory financing payments are less likely (see Table 22 in Appendix 4). Thus there is a 95 percent probability that the total compensatory financing cost of a scheme with 20 million metric tons of grain will be less than $12 billion. Adding the $1.1 billion cost for the grain reserve still yields a figure well below the comparable cost of about $16 billion for a scheme operating solely as a compensatory financing mechanism. Similarly, Table 23, Appendix 4, compares the distributions of the compensatory financing cost of the system for the middle year of its operation (1980) under alternative grain reserve levels. The expected payment during 1980 is $916 million when 20 million metric tons are held in the system compared to $1,229 million when the scheme operates as a compensatory financing mechanism only. Furthermore, with the reserve, availability of less than $3.5 billion will be adequate to cover all requirements 95 percent of the time. Such coverage would require about $5 billion if the system holds no grain.

The share of benefits to member countries has been estimated and presented in Table 8. Since there are two facilities in this food security scheme, there are two calculations of benefit shares: one for the compensatory financing facility and the other for the grain reserve facility of the scheme. * India, for example, accounts for about 17 percent of all compensatory financing paid by the system, and receives, on the average, about one-third of the grain reserves released during high-price years. Morocco ranks second after India and receives about 11.55 percent of the grain released. Benefits from the grain reserve facility of the system are clearly more concentrated than benefits from the compensatory financing facility. Only three countries—India, Morocco and Mexico—receive more than 50 percent of the grain, and 12 countries receive more than 80 percent. Under compensatory financing, seven countries receive 50 percent and 20 countries receive 80 percent of the benefits.

Table 8 provides also an indication of the severity of the food problem in different countries. Recall that the system's grain reserve facility releases grain during high-price years. Should the need for grain in those years be the same for all countries, then each country's share of benefits from the grain reserve facility would be the same as its share of benefits from the compensatory financing facility. This is hardly the

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* Total benefits received by a member country under this scheme expressed in monetary terms are exactly the same as benefits received under the scheme operating as a compensatory financing mechanism only. The composition of benefits is different between the two schemes.

Table 8—Estimated percentage share of benefits when the scheme combines a 20 million ton grain reserve and a compensatory financing mechanism

Country	Percentage Share in Compensatory Financing a/	Percentage Share in Grain Reserves b/	Country	Percentage Share in Compensatory Financing a/	Percentage Share in Grain Reserves b/
1. India	16.88	32.81	15. Cuba	2.36	.43
2. Morocco	6.81	11.55	16. Iraq	1.89	1.72
3. Mexico	4.32	8.19	17. Sudan	1.69	2.26
4. Turkey	4.21	4.59	18. Peru	2.19	.15
5. Korea, Rep. of	5.13	.93	19. Zambia	1.72	1.95
6. Egypt, Arab Rep. of	5.05	.51	20. Tunisia	1.59	2.19
7. Nigeria	4.57	2.06	21. Sri Lanka	1.80	.99
8. Indonesia	3.63	3.61	22. Chile	1.66	.68
9. Bangladesh	3.39	2.34	23. Philippines	1.28	.87
10. Syrian Arab Rep.	2.76	4.52	24. Burma	.99	.95
11. Algeria	3.02	2.60	25. Lebanon	1.06	.07
12. Iran	2.96	2.19	26. Tanzania	.83	.75
13. Brazil	2.46	2.43	27. Malaysia	.98	.13
14. Venezuela	2.40	.52	28. Malawi	.76	.98

Table 8—Continued

Country	Percentage Share in Compensatory Financing a/	Percentage Share in Grain Reserves b/	Country	Percentage Share in Compensatory Financing a/	Percentage Share in Grain Reserves b/
29. Libya	.83	.22	43. Mali	.33	.20
30. Afghanistan	.71	.54	44. Malagasy	.38	...
31. Colombia	.75	.36	45. Niger	.28	.22
32. Upper Volta	.61	.79	46. Ivory Coast	.29	.21
33. Senegal	.65	.51	47. Trinidad	.32	.01
34. Jordan	.54	.57	48. El Salvador	.23	.30
35. Ecuador	.46	.12	49. Angola	.24	.19
36. Bolivia	.47	.04	50. Ghana	.22	.29
37. Zaire	.42	.19	51. Uganda	.21	.24
38. Cameroon	.35	.41	52. Costa Rica	.24	.04
39. Jamaica	.46	.01	53. Nicaragua	.15	.24
40. Dominican Rep.	.45	.02	54. Honduras	.18	.12
41. Cyprus	.35	.32	55. Paraguay	.15	.20
42. Yemen Arab Rep.	.37	.09	56. Guatemala	.19	.07

Table 8—Continued

Country	Percentage Share in Compensatory Financing a/	Percentage Share in Grain Reserves b/	Country	Percentage Share in Compensatory Financing a/	Percentage Share in Grain Reserves b/
57. Panama	.15	.11	62. Sierra Leone	.10	.02
58. Haiti	.13	.05	63. Benin	.07	.03
59. Guinea	.11	.10	64. Gambia	.02	.02
60. Rwanda	.09	.09	65. Chad	.02	.02
61. Liberia	.09	.06			

a/ Computed as the ratio of expected present value of payments received by a country over the expected present value of the total cost of the scheme, multiplied by 100.

b/ Computed as the ratio of expected volume of grain released to a country over the expected volume of all grain released from the grain reserve facility of the system, multiplied by 100.

case, however. Some countries are in greater need of grain during high-price years either because their own production shortfalls push world prices up or because the high variability of their production increases the probability of a shortfall during high-price years. India's share of benefits from the grain reserve is much greater than its share of benefits from the compensatory financing facility because a major shortfall in India will very likely result in high world prices, thus making India eligible to draw from the grain facility of the system. On the other hand, an equal percentage shortfall for a small country does not cause higher world prices, so the probability of concurrently high prices is much smaller.

Cost of the Scheme Under Alternative Rules of Operation

Alternative insurance levels

The criterion for a country's eligibility for compensation from the scheme in a particular year is the comparison of its current cereal import bill with its trend import bill. The preceding analysis assumed an uninsured import bill of 110 percent for all countries; that is, when a country's current import bill exceeds 110 percent of its trend import bill the country is eligible for the amount of this excess. To examine the sensitivity of cost to the level of insurance provided by the scheme, alternative levels of 120 and 130 percent for all countries have been evaluated. * Under these alternatives each country is eligible for compensation from the scheme when its cereal import bill exceeds 120 percent and 130 percent, respectively, of its trend bill.

Table 9 presents the cost of the scheme under these two alternative insurance levels. It also includes, for comparison purposes, some of the cost figures from Table 6 (110 percent uninsured level). The figures show that a higher uninsured level reduces the cost of the scheme substantially. Operating the scheme as a compensatory financing mechanism at a 120 percent uninsured level results in a cost reduction of $760 million compared to operating the scheme at a 110 percent level. A 130 percent level further reduces the cost by $658 million. The cost reduction from higher uninsured levels for a scheme operating with a 20 million metric ton grain reserve in addition to the compensatory financing mechanism are practically the same as those just mentioned. It should be noted, however, that in this case, almost all of the reduction in the total cost of the scheme comes from reductions in its compensatory financing component. In other words, the grain released from the system is the same under all three alternatives. This implies that even in the case of a 110 percent uninsured level, where countries receive compensation for the excess over 110 percent of trend import bills, countries that receive grain from the scheme as part of their compensation are, in fact, facing a cereal import bill greater than 130 percent of their trend import bill.

The distribution of compensatory financing payments is presented in Table 24, Appendix 4. The higher the uninsured level, the less skewed this distribution becomes, although the higher uninsured levels do not significantly reduce the probability of very large payments. This persistence of large

* Although it would be possible under this scheme for countries to select the insurance level desired, this analysis does not compute the cost of a scheme which assigns different insurance levels to different countries.

Table 9—Expected present value of the cost of the scheme operating under alternative insurance levels

Cost Components b/	Scheme Operating as a Compensatory Financing Mechanism Only — Uninsured Import Bill Level			Scheme Operating as a Combination of a Compensatory Financing Mechanism with 20 MT of Grain Reserve a/ — Uninsured Import Bill Level		
	110 percent	120 percent	130 percent	110 percent	120 percent	130 percent
	(million dollars)					
Cost of compensatory financing	5,108	4,348	3,690	4,006	3,247	2,603
Cost of grain reserve						
Acquisition cost c/	. . .	. . .	. . .	1,800	1,800	1,800
Carrying cost d/	. . .	. . .	. . .	775	775	777
Salvage value e/	. . .	. . .	. . .	1,426	1,426	1,436
Total	. . .	. . .	. . .	1,149	1,149	1,141
Total cost of the scheme	5,108	4,348	3,690	5,155	4,396	3,744

a/ The compensations are in the form of funds when the world wheat price is below $200/metric ton. When the world wheat price exceeds $200/metric ton, part of the compensations are in the form of grain valued at the world price. The grain is released to countries that experience greater than 5 percent production shortfalls and in amounts (to the extent available) to bring the physical availability of grain in every country to 95 percent of production trend.

b/ In computing present values a discount rate of 8 percent has been assumed.

c/ An acquisition price of $90/metric ton has been assumed.

d/ The carrying cost was calculated on the basis of a variable rental cost for storage facilities of $10/metric ton per year.

e/ The salvage value of the residual grain in the system at the end of the five-year period was based on the prevailing market price for that year.

payments should be expected since increasing the uninsured level reduces payments received by each country by fixed amounts. These reductions are significant at low payment levels but become less and less significant at higher payment levels.

Alternative rules for grain release

In the preceding analysis two factors trigger the release of grain from the grain reserve facility: (1) the world price of wheat; and (2) individual country production shortfalls. The system releases grain only in years when price rises above $200 per metric ton and then only to countries that experience a shortfall of more than 5 percent during those years. Although these release rules favor grain release when it is most needed, they might be considered conservative, since there is only 20 percent probability that the world wheat price will rise above $200 per metric ton. Moreover, the probability is very low that some countries will concurrently experience shortfalls greater than 5 percent and high grain prices.* Thus, it is interesting to explore alternative release rules for the system. Two alternative grain release rules have been analyzed. In the first, the release price is reduced to $170 per metric ton. (There is a 32 percent probability of exceeding this price.) In the second, the release price is kept at $200 per metric ton, but grain is released to countries with a shortfall greater than 3 percent. Such countries will receive grain, to the extent available in the system, in amounts that bring the physical availability of grain to 97 percent of trend production.

Tables 10 and 11 show the results of this analysis. Changing the release rules has very little impact on the expected total cost of the scheme. There is, however, a significant reduction in the compensatory financing component of the cost, particularly with a reduced grain release price of $170 per metric ton, which reduces this cost by almost half a billion dollars.† This occurs because more grain is released at a lower release price. Even though the net cost of the grain reserve facility is now higher due to the substantial reduction in the salvage value of the left-over grain at the end of the five-year period, there is still some saving in the total expected cost of the scheme (about $150 million). Moreover, changing the release price trigger from $200 to $170 per metric ton results in a higher probability that grain will be available in later years than changing the production shortfall trigger from 5 to 3 percent. Thus, if a choice between these alternative grain release rules should need to be made, reduction in the release price would be preferable.

Finally, Table 25, Appendix 4 depicts the probability distribution of compensatory financing payments. As noted above, there are significant differences in the payments required under alternative grain release rules. As the figures of this table show, however,

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* For example, a country with a 10 percent standard deviation of production variability has a 31 percent probability of experiencing a production shortfall greater than 5 percent. Assuming that this is a small country and thus, its shortfall does not affect the world price, then the probability that its shortfall will coincide with high world price is only 6.2 percent (31 percent x 20 percent).

† This does not imply that a further reduction in the release price will further reduce the cost. Given the probability distributions, there exists an optimum release price (maximizing the revenue of the grain release). This analysis simply implies that the optimum release price is closer to $170 per metric ton than it is to $200 per metric ton.

Table 10—Expected present value of the cost of the scheme operating as a compensatory financing mechanism in conjunction with a 20 million metric ton grain reserve under alternative grain release rules

Cost Components a/	Release Rules		
	Price Greater Than $200/Metric Ton Shortfall Greater Than 5 Percent b/	Price Greater Than $170/Metric Ton Shortfall Greater Than 5 Percent	Price Greater Than $200/Metric Ton Shortfall Greater Than 3 Percent
	(million dollars)		
Cost of compensatory financing	4,006	3,548	3,874
Cost of grain reserve			
Acquisition cost	1,800	1,800	1,800
Carrying cost	775	713	769
Salvage value	1,426	1,068	1,323
Total cost of grain reserve	1,149	1,445	1,237
Total cost of the scheme	5,155	4,994	5,111

a/ A discount rate of 8 percent has been assumed. The excess over 110 percent of trend in each country's current cereal import bill is covered.

b/ This column is duplicated here from **Table 6 for comparison.**

Table 11—Probability of grain reserve availability during high-price years in a scheme operating as a compensatory financing mechanism in conjunction with a 20 million metric ton grain reserve under alternative grain release rules a/

Year	Release Rules		
	Price Greater Than $200/Metric Ton Shortfall Greater Than 5 Percent b/	Price Greater Than $170/Metric Ton Shortfall Greater Than 5 Percent	Price Greater Than $200/Metric Ton Shortfall Greater Than 3 Percent
	(percent)		
1978	98.5	99.1	98.4
1979	95.8	97.0	94.0
1980	93.3	91.5	84.7
1981	70.8	69.5	59.1
1982	62.5	52.2	46.3
Overall probability of grain reserve availability	82.7	81.9	74.2
	Expected Grain Required and Released		
	(million metric tons)		
Total five-year expected grain requirements	6.26	9.96	7.83
Total five-year expected grain released	5.18	8.16	5.81

a/ The excess over 110 percent of trend in each country's current cereal import bill is covered.

b/ This column is duplicated from Table 7.

these differences are a result of probability shifts for low levels of payments. The probabilities of high payments are practically the same under all alternatives considered here.

Sensitivity of the Results to Changes in the Discount Rate and the Carrying Cost

All the analyses of the preceding sections have assumed a discount rate of 8 percent, and a carrying cost for grain of $10 per metric ton per year. These particular values were to some extent arbitrarily chosen. Obviously, more precise figures could be obtained if some important questions of implementation were resolved. For example, the discount rate is a function of the international lending rate, the financial management of the scheme, the degree of involvement of international financial institutions and donor countries, etc. Similarly, carrying costs depend primarily on the location, quality, and extent of underutilized capacity of storage facilities.

It is possible that alternative assumptions on the values of these parameters could modify the conclusions reached. For example, a lower discount rate reduces the opportunity cost of the intitial expenditure for grain acquisition. Thus, the optimum level of grain reserve might be higher. Similarly, a lower carrying cost implies lower total cost for the system as a whole as well as an increase in the optimum size of the grain reserve. The opposite effects should be expected for higher discount rates or higher carrying cost. Because, as shown earlier, the level of the grain reserve has very little effect on the expected total cost of the system, the effect of changing the above two parameters will be explored only for a system operating with 20 million metric tons of grain in conjunction with a compensatory financing mechanism.

The cost components and the total cost of this scheme under alternative discount rates and carrying costs are presented in Tables 12 and 13. As expected, the higher the discount rate and the lower the carrying cost, the lower the present value of the total cost of the scheme. It is instructive to express the effect of these two parameters in marginal terms. From the figures in Table 13 it follows that, on average, each dollar increase in carrying cost per metric ton results in approximately an $82 million increase in the present value of the total cost of the system. Similarly, the present value of the total cost of the scheme is reduced by approximately $42 million for each percentage point increase in the discount rate.

Although altering the values of these parameters causes some variation in the cost of the scheme, from a practical point of view, this refinement of the results is not crucial at this stage. Other issues, more qualitative and political in nature, are far more important in the implementation of this scheme.

Table 12—Expected present value of cost components of a scheme operating as a compensatory financing mechanism in conjunction with a 20 million metric ton grain reserve under alternative discount rates and per unit carrying costs [a/]

Alternative Discount Rates	Cost of Compensatory Financing	Cost of the Grain Reserve						
		Acquisition Cost	Total Carrying Cost Under Alternative Per Unit Carrying Costs ($/MT/Year)					Salvage Value
			2.5	5.0	7.5	10.0	12.5	
(percent)	(million dollars)							
2	4,559	1,800	215	429	644	859	1,074	1,792
4	4,360	1,800	207	415	621	829	1,036	1,658
6	4,177	1,800	200	401	601	801	1,002	1,536
8	4,006	1,800	194	388	582	775	970	1,426

a/ The excess over 110 percent of trend in each country's current cereal import bill is covered.

Table 13—Expected present value of total cost of a scheme operating as a compensatory financing mechanism in conjunction with a 20 million metric ton grain reserve under alternative discount rates and per unit carrying costs [a/]

Alternative Discount Rates	Alternative Per Unit Carrying Cost ($/MT/Year)				
	2.5	5.0	7.5	10.0	12.5
(percent)			(million dollars)		
2	4,782	4,996	5,211	5,426	5,641
4	4,709	4,917	5,123	5,331	5,539
6	4,640	4,841	5,041	5,242	5,442
8	4,574	4,769	4,963	5,155	5,350

a/ See Table 12 for the components of total cost. The excess over 110 percent of trend in each country's current cereal import bill is covered.

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CONCLUSIONS

Before discussing methods of funding a food insurance scheme of the type described in this paper, the different cost figures derived in the previous sections must be put into proper perspective. One important distinction needs to be made at the start. Automobile, property, or health insurance plans involve a very large number of participants, and the risk factor is continuous over time.* Thus, the probability that the actual cost will equal expected cost within a given period is extremely high. An international food insurance scheme, on the other hand, involves a limited number of participants and a non-continuous risk factor.† As a result, the actual cost of operating the scheme for a finite period might differ significantly from its expected cost.

Whatever the form of its financial resources (cash in hand, scheduled premium payments, borrowing capacity, or standby pledges), a food insurance scheme of the type described in this paper will not be established unless it can function at a cost that seems reasonable to its funders. If a high degree of certainty is desired that funds will be available to meet the objectives of a food security scheme, the amount of these funds will have to be very large, even though there is little likelihood that the scheme will actually cost that much. If a lower degree of certainty is acceptable, the potential cost of the insurance scheme will be considerably lower, and the reduced initial capital requirements are more likely to seem reasonable to probable funders of the scheme. In the event that the scheme's funds do not fully cover requirements in some years, target consumption will have to be adjusted proportionately for all participating countries. Since funders will certainly set an upper limit to the financial capacity of any food insurance scheme, the question then becomes, what is the best use of a given level of funds?

To indicate the range of options which funders might want to consider, Table 14 and Figure 2 present the probabilities associated with different cost levels above the expected cost for six scenarios: three insurance levels without reserves, and three insurance levels with a grain reserve of 20 million tons. These clearly show that the higher the probability that the objectives of the scheme

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* This is so because the probabilities of an automobile accident, a house catching fire, or an individual having a heart attack are not correlated among themselves and among different insurance policy holders. The fact that an individual has an expensive medical bill during a given month does not mean that his next-door neighbor will also have a high bill during the same month. Furthermore, if several individuals insured in the same insurance company happen to get sick at the same time, this would not affect the price of medical services, and therefore the per unit cost to the insurance company would not rise.

† Crop production outcomes have a time cycle of one year, and are to some degree, correlated among neighboring countries. In addition, favorable or unfavorable weather worldwide during a particular year has an impact on cereal prices, and thus, the per unit cost to a food insurance scheme can vary substantially from one year to the next.

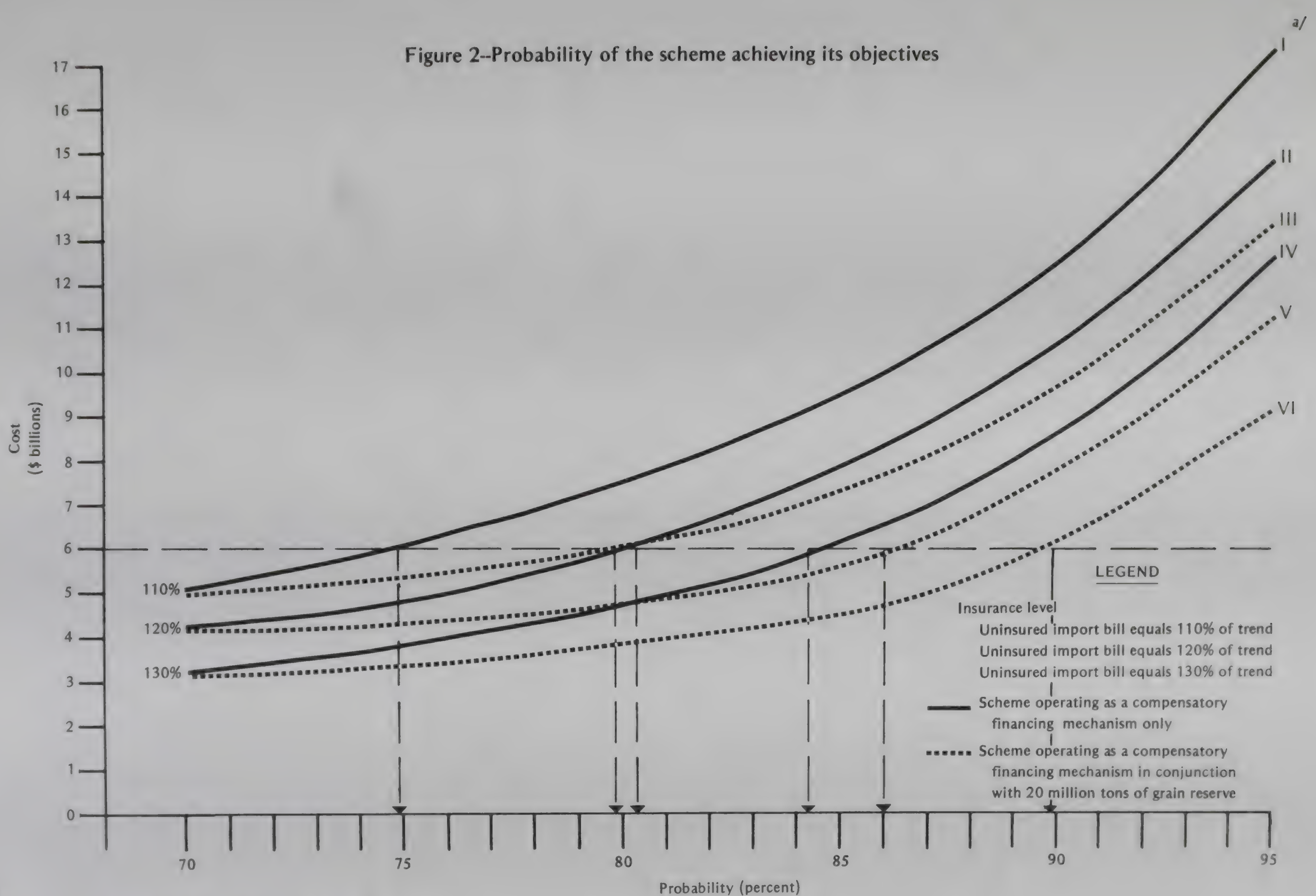
Table 14—Funds required to attain a given probability that the scheme will achieve its objectives under alternative methods of operation [a/]

Alternative Scenarios on the Operation of the Scheme	Expected Cost	Probability of the Scheme Achieving its Objectives (percent)					
		70	75	80	85	90	95
		(billion dollars)					
Scheme operating as a compensatory financing mechanism only, with uninsured import bill of							
I. 110% of trend	5.11	5.1	6.1	7.3	9.4	12.1	16.7
II. 120% of trend	4.35	4.1	4.9	6.0	7.9	10.7	14.5
III. 130% of trend	3.69	3.3	3.9	4.8	6.4	8.7	12.5
Scheme operating as a compensatory financing mechanism in conjunction with 20 MT of grain reserve, with uninsured import bill of [b/]							
IV. 110% of trend	5.15	5.1	5.6	6.1	7.0	9.5	13.2
V. 120% of trend	4.40	4.1	4.4	4.8	5.7	7.7	11.2
VI. 130% of trend	3.74	3.3	3.6	3.9	4.7	6.1	8.9

a/ The scheme attains its objectives when it has adequate funds to compensate member countries under its rules of operation.

b/ The cost figures under scenarios IV,V and VI include also the net cost of the grain reserve (about $1.1 billion). Grain is released in years when world price exceeds $200 per metric ton, to countries that experience greater than 5 percent production shortfalls in those years and in amounts that will bring the physical availability of supplies (to the extent available in the system) to 95 percent of trend production in all countries.

Figure 2--Probability of the scheme achieving its objectives



a/ For definition of alternative scenarios for operating the scheme see Table 14.

will be met, the higher the marginal cost of food insurance. For example, under scenario II (scheme operating solely as a compensatory financing mechanism with an uninsured import bill of 120 percent of trend) an additional financial capacity of $0.8 billion increases the probability level from 70 to 75 percent, whereas increasing this probability from 90 to 95 percent requires $3.8 billion.

There is, however, a trade-off between the level of insurance provided and the probability that the objectives of the scheme will be met. For a given financial capacity, a high degree of insurance implies a high risk of depleting funds during the last years of the five-year period, thus favoring countries that happen to draw from the scheme early in the period. Therefore, lower insurance coverage (uninsured import bill of 130 percent of trend) with a high probability (90 to 95 percent) of defending the scheme's stated objectives should be preferable to high insurance coverage (uninsured import bill of 110 percent of trend) with a lower probability (70 to 75 percent) of achieving the objectives.

Another consideration is the presence or absence of a grain reserve in the system. Although a grain reserve has virtually no effect on the probability that the scheme will meet its objectives if funding is provided at the expected cost level, additional funding above the expected cost makes a scheme with a grain reserve preferable since it provides a higher probability of achieving its objectives. This effect is greater the larger the size of the reserve. In addition, as shown earlier, a larger reserve provides a higher probability of maintaining supply availability in eligible countries at 95 percent of trend production during high-price years. For these reasons, if a grain reserve were established in conjunction with a compensatory financing mechanism, a grain reserve level of 20 million metric tons for developing countries is suggested.

If it is reasonable to assume that most countries can manage import bill overruns up to 130 percent of the trend import bill in some years, then the expected present value of the cost of the scheme amounts to about $3.7 billion, of which about $1.1 billion is the cost of a 20 million metric ton grain reserve. This level of funding implies a probability of at least 75 percent that the scheme will successfully defend its objectives. A probability level of 90 percent might require up to $2.4 billion more during the next five-year period.

A crucial component in the success of this scheme is the source of funds needed for its operation. Three alternative approaches to financing the scheme are discussed: (1) self-financing by participating countries, (2) financing primarily by developed countries, with some contributions from developing countries, either collectively or through a scheme that would incorporate existing food aid programs, and (3) financing through a compensatory financing facility of the International Monetary Fund (IMF).

Under the first alternative, member countries pay annual premiums in proportion to their expected benefits during the five-year period. Countries could pay equal premiums every year or, depending on their year-to-year overall foreign exchange position, they could pay variable annual premiums, larger when foreign exchange position is good, smaller when it is poor. Based on expected total withdrawals (Table 15), annual premiums by country can be computed. For example, if India had to pay an equal annual premium for the next five years, that premium would range from about $206 million to about $245 million, depending on the level of insurance provided by the scheme. The funding provided by this approach would

Table 15—Estimated percentage share of benefits and present value of expected total withdrawals by country, 1978-82 [a]

Country	Uninsured Import Bill				Country	Uninsured Import Bill			
	130% of Trend		110% of Trend			130% of Trend		110% of Trend	
	Share of Benefits	Expected Total Withdrawal	Share of Benefits	Expected Total Withdrawal		Share of Benefits	Expected Total Withdrawal	Share of Benefits	Expected Total Withdrawal
	(%)	($ millions)	(%)	($ millions)		(%)	($ millions)	(%)	($ millions)
India	24.07	900.2	20.80	1071.2	Venezuela	1.49	55.7	1.99	102.5
Morocco	9.72	363.5	7.76	399.6	Cuba	1.46	54.6	1.94	99.9
Mexico	5.74	214.7	5.02	258.5	Iraq	1.62	60.6	1.84	94.8
Turkey	4.87	182.1	4.24	218.4	Sudan	2.34	87.5	1.79	92.2
Korea, Rep. of	3.27	122.3	4.23	217.8	Peru	1.31	49.0	1.75	90.1
Egypt, Arab Rep. of	3.07	114.8	4.08	210.1	Zambia	2.31	86.4	1.75	90.1
Nigeria	3.23	120.8	4.01	206.5	Tunisia	1.85	69.2	1.71	88.1
Indonesia	3.63	135.8	3.63	186.9	Sri Lanka	1.31	49.0	1.63	83.9
Bangladesh	2.67	99.9	3.17	163.3	Chile	1.11	41.5	1.44	74.3
Syrian Arab Rep.	3.44	128.7	3.13	161.2	Philippines	1.00	37.4	1.19	61.3
Algeria	2.44	91.3	2.92	150.4	Burma	.95	35.5	.98	50.5
Iran	2.29	85.6	2.77	142.7	Lebanon	.63	23.6	.84	43.3
Brazil	2.56	95.7	2.41	124.1	Tanzania	.72	26.9	.81	41.7

Table 15—Continued

Country	Uninsured Import Bill				Country	Uninsured Import Bill			
	130% of Trend		110% of Trend			130% of Trend		110% of Trend	
	Share of Benefits	Expected Total Withdrawal	Share of Benefits	Expected Total Withdrawal		Share of Benefits	Expected Total Withdrawal	Share of Benefits	Expected Total Withdrawal
	(%)	($ millions)	(%)	($ millions)		(%)	($ millions)	(%)	($ millions)
Malaysia	.58	21.7	.80	41.2	Dominican Rep.	.27	10.1	.36	18.5
Malawi	1.03	38.5	.80	41.2	Cyprus	.28	10.5	.34	17.5
Libya	.53	19.8	.70	36.0	Yemen Arab Rep.	.24	9.0	.31	16.0
Afghanistan	.63	23.6	.67	34.5	Mali	.26	9.7	.30	15.4
Colombia	.54	20.2	.66	34.0	Malagasy	.23	8.6	.30	15.4
Upper Volta	.72	26.9	.64	33.0	Niger	.23	8.6	.28	14.4
Senegal	.51	19.1	.61	31.4	Ivory Coast	.22	8.2	.27	13.9
Jordan	.47	17.6	.55	28.3	Trinidad	.19	7.1	.25	12.9
Ecuador	.29	10.8	.38	19.6	El Salvador	.30	11.2	.24	12.4
Bolivia	.28	10.5	.37	19.1	Angola	.23	8.6	.23	11.8
Zaire	.29	10.8	.37	19.1	Ghana	.27	10.1	.23	11.8
Cameroon	.35	13.1	.36	18.5	Uganda	.28	10.5	.22	11.3
Jamaica	.27	10.1	.36	18.5	Costa Rica	.15	5.6	.20	10.3

Table 15—Continued

Country	Uninsured Import Bill				Country	Uninsured Import Bill			
	130% of Trend		110% of Trend			130% of Trend		110% of Trend	
	Share of Benefits	Expected Total Withdrawal	Share of Benefits	Expected Total Withdrawal		Share of Benefits	Expected Total Withdrawal	Share of Benefits	Expected Total Withdrawal
	(%)	($ millions)	(%)	($ millions)		(%)	($ millions)	(%)	($ millions)
Nicaragua	.18	6.7	.17	8.8	Rwanda	.09	3.4	.09	4.6
Honduras	.13	4.9	.16	8.2	Liberia	.07	2.6	.08	4.1
Paraguay	.21	7.9	.16	8.2	Sierra Leone	.06	2.2	.08	4.1
Guatemala	.12	4.5	.16	8.2	Benin	.05	1.9	.06	3.1
Panama	.11	4.1	.14	7.2	Gambia	.02	0.7	.02	1.0
Haiti	.09	3.4	.11	5.7	Chad	.03	1.1	.02	1.0
Guinea	.11	4.1	.11	5.7					

Note: Countries are listed in descending order of benefits drawn at the 110 percent uninsured levels.

a/ Expected cost with: 110 percent uninsured import bill $5,150 million
130 percent uninsured import bill $3,740 million

cover only the expected cost of the scheme, so there would be about 25 percent probability that the scheme's funds would run out. If funds ran out, then the scheme would either have to borrow the cost overruns up to the limit that had been set, or it would have to adjust compensation to eligible countries so that all shared the burden proportionally.

The longer the life of the scheme, the closer the cumulative disbursements at any point of time will be to the cumulative premiums paid in; over a sufficiently long time the scheme itself would be able to repay past debts or to meet by itself higher than expected current costs. However, if the scheme's life is abruptly terminated after the initial five-year period, the scheme will very likely be left with either a surplus or a deficit both in overall receipts versus disbursements and in the distribution of benefits to individual countries. If the scheme has a balance other than zero on termination, then surpluses should be refunded to and deficits paid by member countries according to their net contributions to the scheme.

In practice, most low income countries are not able to participate in a self-financed scheme without help from developed countries. A food security scheme designed to maintain consumption in developing countries when world prices are high would permit these countries to rely on commercial imports for an increasing percentage of their growing food requirements. Therefore it would be to the advantage of grain exporters in particular to contribute to such a scheme.

Under the second funding alternative, developed countries could provide assistance in a number of ways. If they chose to do so, they could finance the scheme along with the richer of the developing countries without reference to the distribution of benefits among recipient countries. In this case, donor countries could simply make a collective commitment to finance the scheme at an agreed upon level. Contributions could be made either in the form of money or in the form of grain to set up a reserve on behalf of the scheme. The cost of setting up the grain reserve could perhaps be the responsibility of the major grain exporters.

Another possibility would be for donor countries to make commitments to pay a specific percentage of the premiums required from low income countries. A collective effort by developed countries to subsidize the scheme in this way would be desirable from the point of view of recipient countries because it would stipulate a regular flow of financial assistance on terms known in advance. But donor countries might not, for various economic and political reasons want to commit themselves to this approach. Many of them might prefer to integrate existing food aid commitments into the scheme rather than or in addition to providing direct financial subsidies to eligible participants. At present, food aid flows are not always responsive to the requirements of recipient countries for which they are intended. Incorporating variable food aid commitments in a food security scheme could remedy this situation.

For countries willing to contribute to the financing of a food insurance scheme through their food aid programs, there are several options.Food aid can be used instead of funds to subsidize the annual premium payments of low income countries. In certain years, the donor nation might make a food aid contribution to a beneficiary country in lieu of a dollar payment to the food insurance scheme. Assume, for example, that a country is obligated to pay an annual premium of \$10 million to the food security scheme in order to guarantee a certain degree of domestic food security, and that a donor country has pledged a contribution of \$5 million (half of the annual premium) on

behalf of this country. Suppose that during a normal year the country needs to import $20 million worth of food to meet its consumption targets. Thus, during a normal year this country will have to spend a total of $25 million for food imports and its participation in the food security scheme. If during a particular year an excessive grain supply in the donor country makes it more desirable for the donor to make its pledged contribution in the form of grain, it can do so by contributing $5 million worth of grain directly to the beneficiary country. The beneficiary country will then have to import only $15 million, and this $5 million savings on its normal import bill plus the $5 million that it has allocated for its participation in the insurance scheme will cover its required premium for that year.

Food aid can also contribute directly to the stabilization of domestic food supply in the recipient country, so that the country will seek a lower degree of protection from the food insurance scheme and thus reduce its annual premium payments. Because domestic supply fluctuations in the recipient country will not in general coincide with the capacity of the donor country to provide food aid, such aid could be used when available to build up a reserve in the recipient country. If stocks created from food aid contributions provided protection against a certain level of domestic production shortfall, then this country should seek coverage from the food insurance scheme in excess of the insurance it provided itself. The premiums needed in this case could be considerably lower than those for full coverage.

Whatever the financing arrangement, not all of the funds would have to be provided in the form of paid-up capital. Donor country commitments could take the form of securing the scheme's borrowing capacity.

A practical way to initiate negotiations would be for a group of interested countries to present a food insurance proposal to the International Wheat Council and/or to the Grain Subgroup of the Multilateral Trade Negotiations, presenting the proposed scheme as a means of making special provision for developing countries within the more general agreement being negotiated.

A third alternative for funding a food security scheme is through a compensatory financing facility within the IMF. This could be done by creating a new facility specifically to cover overruns in cereal import bills. Or the cereal import bill could be taken into account along with fluctuations in commodity export earnings in determining whether a country is eligible for compensatory financing from the existing facility. Funding through the IMF's compensatory financing facility is a reasonable and just solution because it takes into consideration the foreign exchange position of a country in a given year. More important, the mechanisms that could put such a scheme into operation have already been established and tested, thus precluding the need to establish a vast new bureaucracy.

In addition to funding arrangements already discussed, several other issues will require attention. The foremost problem to be resolved is the identification of reliable data sources to be used in determining which countries are eligible for compensation and the exact amounts they are eligible for each year. For the initial five-year period, production trends and consumption projections could be estimated with a high degree of accuracy. With some refinement the figures developed in this analysis could be used. The only remaining problem associated with data will then be the accuracy of future annual production figures. An international authority would have to determine whether a reported production shortfall is the result of genuine adverse weather

conditions, or whether it results from a country cutting back resources in cereal production or deliberately under-reporting its production performance. Rather than creating a new bureaucracy, an authority already competent to assess cereal production and consumption data submitted by participating nations should take on administrative responsibility for the scheme. Over time, a country's consistent falling behind in production performance would be reflected in lower production trend and consequently, higher import trend. Since each country is itself responsible for covering a certain percentage of its trend import bill, it would be discouraged from under-reporting, knowing that under-reporting would effect its eligibility for compensation in future years. Although this effect might not be very important within the time period of one agreement, it would have a bearing on the negotiation of future agreements.

Another issue deals with the administration of grain, if grain stocks are held in the system. Because current world prices are relatively low, it was suggested that the system could start with the desired grain reserve in stock. A delay in grain acquisition is almost certain to mean higher acquisition costs. A $200 per metric ton price has been assumed to trigger the release of grain, and only to countries that experience more than 5 percent production shortfalls during high-price years. An alternative trigger price of $170 per metric ton and an alternative production shortfall level of 3 percent were also explored. Although these alternatives did not have a significant effect on the expected cost of the scheme, they resulted in a slightly less skewed distribution of compensatory payments.

The location of a reserve is another issue that usually emerges in discussions of internationally held grain reserves. Ideally, the grain reserve should be located as close as possible to countries that are more likely to call upon it, assuming that high quality storage facilities exist. Alternatively, on the assumption that grain exporting countries would share in the cost of the scheme either by collectively providing part of the grain reserve or by integrating into the scheme their current food aid programs as discussed earlier, grain exporters could hold part of the grain reserve on behalf of the scheme in existing storage facilities. Major grain exporters might be willing to waive carrying costs by including them in the cost of achieving their domestic agricultural policy objectives. Thus, though the location of grain reserves is a politically sensitive issue for reasons of self-reliance, it appears that from a practical point of view negotiations should focus on a few storage sites close to large contributors and to large expected users of the grain. Countries could minimize the disadvantages of distant location of the international reserve by holding small reserves of their own to supplement those of the scheme.

Finally, food deficit, developing countries will have to develop internal policy instruments to insure that the steady flow of grain imports obtained by a country's participation in the food insurance scheme reaches the poorest part of its population. In most developing countries agriculture generates a large portion of the income of the poor, so years of poor harvests imply lower buying capacity for a large portion of the population. If the reduction in consumption caused by this decline in effective demand is greater than that tolerated by the food security scheme, countries will need to operate internal food subsidy programs during these years. In addition, since the added supply of grain from an external source will keep prices lower than they would have been otherwise, farm incomes will be rather low (a combination of poor harvests and prices

depressed by added supplies). Thus, aside from providing assistance to consumers, domestic policy would have to provide income compensation to grain producers to negate possible adverse effects on their earnings.

In summary, this paper has presented a food insurance scheme to deal with the food insecurity problem of food deficit, developing countries; a scheme whose cost proves to be within the reach of the international community. The world food problem is no temporary phenomenon, and the earlier a comprehensive effort, such as the one suggested here, is made, the better. The environment for initiating this effort may never be more favorable in terms of currently available grain supplies. Should this effort prove fruitful, more countries will undoubtedly seek to join, and the chances of alleviating mankind's ultimate problem will be greatly enhanced.

Appendix 1

OVERVIEW OF PAST APPROACHES TO THE INSTABILITY OF GRAIN MARKETS

Welfare Effects of Commodity Price Stabilization

Much of the early work on the desirability of commodity price stabilization brought out the conflict of interest between producers and consumers. Welfare analysis was used to determine benefits and costs from price stabilization and their distribution between the two groups within a closed economy framework. Massel (1969), building upon the original work by Waugh (1944) and Oi (1961), assumed demand and supply linear and subject to additive disturbances, and showed that the elasticities of demand and supply and the source of the instability determine which group gains from stabilized prices. Despite the divergence of economic interests between producers and consumers with regard to stabilized prices, the gainers can compensate the losers so that both groups would be better off with than without price stability. The same conclusions were reached independently by Samuelson (1972).

Since 1972 there have been a number of new developments in the economic analysis of price stabilization. First, less stringent assumptions have been introduced to make analysis more realistic for today's world; and second, the international dimensions of the problem have been brought into perspective. In this context, the conflict of economic interests from price stabilization is not only a domestic issue but also an international one.

Heuth and Schmitz (1972) extended the Waugh-Oi-Massel closed economy model to an international trade model. Their conclusions are basically similar to those of Massel. That is, whether or not an individual country gains from stabilization basically depends upon the source of the instability. A country gains from price stabilization if the source of instability is domestic (either demand or supply) but loses if the source of instability is foreign. Domestic producers gain from price stabilization if they are the source of the instability, and they lose if domestic demand and/or foreign demand are the sources of instability. On balance, both countries gain from price stabilization, provided that international and domestic compensations are made from gainers to losers.

The question of who gains and who loses from price stabilization can only be answered by empirical investigation. Konandreas and Schmitz (1978) have empirically tested the Heuth and Schmitz model for the United States for the period of 1954 to 1972. On the basis of their econometric analysis, United States producers and the U.S. as a whole would gain from feedgrain price stabilization, and perhaps also from wheat price stabilization, although this is less clear. These results are consistent with U.S. policy before 1972, when the main source of variability in grain markets was U.S. grain production, and the U.S. government held large stocks to maintain a stable price floor in the producer's interest. The Konandreas and Schmitz study does not fully capture the effect of increased

variability in foreign demand since 1972 because such high foreign demand fluctuations were not experienced during the period of their analysis.

These analyses assume that demand and supply curves are linear and that random disturbances are additive. Gray (1974) noted the significance of the shape of the demand curve for the welfare implications of price stabilization when he speculated that the demand curve for grains may grow steeper at higher price levels. Just et al. (1977) have analyzed the non-linear case with an international trade model. As in the linear case, exporters and importers taken together gain from price stabilization. Broadly speaking, importers tend to gain while exporters tend to lose, and benefits seem to shift from producers to consumers in both countries. The welfare implications of price stabilization have been further investigated by incorporating expectations into the supply function. Turnovsky (1974) experimented with adaptive and rational expectation schemes and found a theoretically ambiguous distribution of benefits in this case.

Reutlinger (1976) employed an aggregate simulation model to calculate the effectiveness of an international wheat stock on stabilizing prices. The model is run at different stock levels, using quantitative triggers and estimates the probability of price stabilization within specified ranges. For example, a reserve stock target of 30 million tons, acquired when production exceeds 355 million tons and released when it falls below 335 million tons, stabilizes price within a range of \$115 to \$188 with a 78 percent degree of assurance and a mean price of \$138 per ton. But stock levels that are optimal in terms of direct costs and welfare benefits are likely to be too low to afford a satisfactory degree of price stabilization. The cost of storage to the economy rises rapidly above stock levels of 5 to 10 million tons. Further, a high degree of stabilization seriously imbalances the distribution of gains and losses in favor of consumers and against producers. In the above example, consumers would have to be taxed fifty cents per ton to cover the net loss of the storage operations, and producers could expect to lose thirty-five cents per ton.

Reutlinger notes that both producers and consumers might be willing to pay these costs in order to obtain stabilization of their effective incomes. Also, if more stable prices led to better resource allocation and reduced inflation, or if they reduced the cost of quantitative food aid commitments, the costs to the economy might be worth bearing. He also cautions that the cost/benefit results can be strongly affected by the sequence of good and bad harvests after the initial investment, and by the elasticities assumed for different segments of the demand curve, neither of which can yet be specified reliably. Finally, the effectiveness of buffer stock programs operated with insurance-oriented storage rules was also investigated; it was shown that with such a scheme adequate protection against extreme world grain production shortfalls could be achieved.

Using a kinked demand curve, and adjusting for country and world market price differentials resulting from trade barriers, Sarris et al. (1977) also experiment with the price stabilization effects and costs of different sizes of wheat and feedgrain stocks. On the basis of their results, they argue that an international wheat reserve of up to 15 million tons could stabilize prices within a wide band and imply greater welfare benefits than associated costs. This reserve level would reduce price fluctuations by about one-third, keeping them within a band of roughly \$110 to \$180 per ton at current prices.

For modeling purposes they assume that an international buffer stock agency would manage the reserve through buying and selling operations whose precise rules would not be made public, because of the need to prevent offsetting market interventions by other buyers and sellers. Over time, wheat importers would be slight gainers while exporters would be slight losers, but the amounts involved are minimal. A feedgrain reserve would reverse the country distribution of net gains and losses, with importers losing and exporters gaining. Thus, it might be advantageous to create a joint reserve, even though feedgrain prices would be much less responsive to the operation of a buffer stock than wheat prices.

Simulation Analysis Experiments on International Grain Reserves

Another body of literature employs simulation analysis with mechanical models that approach the reserves problem from the standpoint of supply availability. These models do not deal with price stabilization from the point of view of its welfare implications as such; rather, they treat reserves as a means of ensuring that certain consumer groups will not be cut off from supplies when harvests are low. This was a logical reaction to the 1972-74 food crisis.

One of the first analytical responses to that crisis was the study by the Economic Research Service of the United States Department of Agriculture, by Bailey et al. (1974). This study concerns itself with the level of reserve stocks required to provide various degrees of supply security, and estimates the storage cost of each alternative considered. It points out that when the ratios of United States wheat and corn carry-out to total use fall below 20 percent, there is a significant increase in prices, but it does not consider price stabilization as an objective, nor does it discuss the specific stabilization effects of reserve stocks as such.

The study tries a number of different calculations to estimate the effect of a United States reserve program on supply availability during the period 1950-69, had such a program been in effect. The size of the reserve is fixed as a percentage of U.S. trend production, and rises gradually over time. Calculations are made with stock level targets ranging from 8 to 12 percent of U.S. trend production. At 8 percent, for example, the target size of the reserve would have risen from 9.9 to 16 million metric tons, whereas at twelve percent it would have risen from 13.9 to 23 million metric tons. Reserve stocks would be accumulated each year up to the established percentage limit, to the extent permitted by the availability of other stocks plus the level of current production. Out of a total world shortfall* of 179.4 million metric tons for this period, 79 percent would have been covered by the smaller reserve (8 percent of trend production) at a cost of $4.52 per metric ton, and 95 percent by the larger (12 percent) reserve at a cost of $5.60 per metric ton.

This study also identifies some important policy issues and raises practical questions about how to implement a grain reserve program. Policy questions that the authors raise include: what kind of demand should be supported (domestic, commercial export, foreign aid)? How much uncertainty and adjustment should be allowed? What price level would be protected?

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* World shortfall is computed as the summation of actual shortfalls in major exporting countries (United States, Canada, Argentina, and Australia) and shortfalls in excess of 5 percent of trend production in all other countries. For the latter, it is assumed that policies will be adjusted so that production variations in excess of 5 percent of trend will be absorbed by adjustments in consumption.

A follow-up of this approach is contained in a later USDA publication, World Food Situations and Prospects, which presents data for the period 1960-73 showing that if wheat, rice, and coarse grains are taken separately, a combined reserve of 80 million metric tons would have been needed to cover 95 percent of world production shortfalls. If all grains are assumed to be perfectly substitutable for each other, the reserve requirement would have been 56 million metric tons. Substantially smaller amounts would have been needed if the reserve were used only to cover shortfalls in trend imports, and it is estimated that no more than 10 million metric tons would be needed for a famine relief reserve. Like the earlier USDA study, a number of practical questions are addressed.

This study argues that economically optimum stock levels likely to be held by the private sector will not be large enough to provide adequate supply security, and that while several different cost-sharing formulas might be applied, a reserve stocks system would operate most efficiently if the stocks were located in only a few major exporting and importing countries. The idea that improvement in the market information system might help to reduce speculative activity is stressed, but the possible stabilizing effects of freer trade policies on world grain markets is not mentioned.

Eaton et al. (1976) estimate the stock levels needed for various degrees of food security in a world where trade, transport, or distribution barriers do not exist and grains are perfectly substitutable. Data for the period 1960-74 are used. The authors note that because of these ideal assumptions, the reserve requirements computed are unrealistically low. Reserves of 58 million metric tons would be sufficient to cover 98 percent of production shortfalls in a free trade world between now and the end of the century, and only 5 million metric tons would cover 95 percent of probable future shortfalls.

Johnson (1976) believes that in an ideal free trade world there would be little need for grain reserves in most years. However, since governments do generally try to shield their domestic markets from the full price effect of production fluctuations he feels that some special arrangements are needed to help developing countries stabilize grain consumption within a reasonable range. His views on the kind of arrangement needed appear in a collaborative work by Danin et al. (1975). They propose a reserve scheme which would provide developing countries with a specified level of insurance against their own production shortfalls. Their study shows that optimal carryovers for individual developing countries would be greatly reduced if an international insurance scheme were in effect. On the basis of their findings, they propose that the United States and other developed countries guarantee coverage of production shortfalls in developing countries greater than a given percentage of their production trends.

Following Gustafson (1958), they define optimal carryover as that amount for which the expected marginal cost of holding an additional ton of grain equals the expected marginal gain which would result from preventing a price increase. A linear demand curve with a price elasticity of −0.1 was assumed for all grains, and actual production for the years 1948-73 was used to calculate trend production. Nonvariability of trade outside the country or region was assumed in order to show the implications of letting stocks bear the entire burden of adjustment of their own production variability. No distinction is made between foodgrains and coarse grains, on the assumption that they are highly substitutable for each other.

The level of country disaggregation af-

fects the results. For example, without an insurance scheme in effect, the expected annual amount of carryover in four developing country regions, treated separately, would equal 13.7 million metric tons in 1975, with a 95 percent probability that the maximum would not exceed 34.5 million metric tons. However, if developing countries are treated as a single, free-trade region, the expected yearly carryover is only 5 million metric tons, and 95 percent of the time the maximum does not exceed 15 million.

In collaboration with Cochrane, Danin (1976) has extended the work he began with Johnson into a full-scale grain reserve model. He projects the reserve stock levels and degree of price stabilization for the period 1975-85, estimating that by 1985 the degree of price variation around a target price of $100 per ton could be reduced from 27 percent to as low as 10 percent with the reserve growing gradually to 75 million metric tons by that time. A reserve level of 39 million tons in 1985 would reduce price variation to around 19 percent. A beginning reserve stock would produce an immediate reduction in price variability, if desired, but for the long-run a beginning grain reserve is not necessary to achieve this objective. Danin also stresses the importance of the price elasticity assumed, i.e., the more elastic the demand, the more a given reserve level reduces price variability.

The significance of this work is that it shows the degree to which pooling reserves among countries reduces the aggregate optimum carryover level. Further, when developing countries reserve supply guarantees covering a percentage of their production shortfalls, these optimum carryovers are substantially reduced. Finally, this study shows that free trade among developing countries would be the most effective policy for reducing maximum carryover levels.

An insurance scheme which would have covered shortfalls in excess of 6 percent of trend production in four developing country regions from 1954 through 1973 would have made zero payments 65 percent of the time, and would have paid less than 2.5 million metric tons 80 percent of the time. The maximum payment required would have been 9.2 million tons, an amount that would either have to be carried in an international reserve or made available to developing countries by purchases in commercial markets if the scheme were to produce the intended results. Had the scheme been in effect, 95 percent of the time the maximum optimal carryover for the four regions would have been less than 23 million tons, and for developing countries treated as a single free-trading region less than 14 million tons.

Walker and Sharples (1976) investigate the consequences of a reserve system operated unilaterally by the United States. Two systems are evaluated, one operated with price triggers and the other operated with quantity triggers.

For the reserve system based on price triggers, the price range for wheat is set at $80 to $140 per metric ton, and for corn at $70 to $120 per metric ton. For the simulation period 1976 to 1982, the average wheat price is the same ($110 per ton) whether or not the government accumulates stocks, but the degree of price variability is reduced by half when government stocks are held. For feedgrains, the average price drops from $100 to $95 per ton if buffer stocks are held, and the degree of variability is again reduced by almost half. Slightly more wheat moves into export with stocks than without, and slightly less feedgrain. The average size of the combined stock is 41 million metric tons (18 million wheat and 23 million feedgrains), although the maximum stock size could occasionally rise to more than 80 million metric tons. The net annual cost for running this system is $389 million,

though in some years it could exceed $2 billion. A size limit is not imposed on stocks. Such a limit would reduce costs, but would increase the chances of extremely high prices from time to time.

For the reserve system based on quantitative triggers, two rules are evaluated: one in which stocks are accumulated and released when world production deviates more than two percent above or below trend, and the other when production deviates by more than five percent. In both cases, net storage costs are about the same as with price triggers, but less price stabilization is achieved.

Finally, Trezise (1976) proposes a wheat and coarse grain reserve of 64 million metric tons, rising to about 80 million metric tons by 1980. This reserve would insure against all sources of instability: a wheat shortfall in importing countries, a poor coarse grain harvest in the United States, or a serious failure of the world rice crop. He concludes that to be workable, a reserve system probably must be multilaterally financed and managed, and recommends ways in which a multilateral reserve arrangement might be operated without interfering with normal market forces.

Appendix 2

PROJECTED DEMAND, TRENDS AND VARIABILITY IN CEREAL PRODUCTION

Projected cereal demand for each country is obtained on the basis of population growth, GNP growth, and income elasticities. The expression used is as follows:

(1)

$$\overline{C}_{it} = N_{it} \left[c_{oi\ 1975} \cdot (1 + r_i \cdot g_{oi})^{t-1975} + c_{ei\ 1975} \cdot (1 + r_i \cdot g_{ei})^{t-1975} \right]$$

where

$\overline{C}_{it}$ = projected cereal demand of the ith country in year t;

N_{it} = projected population of the ith country in year t;

$c_{oi\ 1975}$, $c_{ei\ 1975}$ = per capita trend foodgrain and feedgrain consumption, respectively, of the ith country in 1975.

r_i = annual growth rate of real per capita GNP of the ith country.

g_{oi}, g_{ei} = income elasticities of foodgrains and feedgrains, respectively, of the ith country.

Per capita trend consumption for foodgrain and feedgrain were obtained by fitting logarithmic time trends using actual 1960-75 data. The values of these trends as well as the values of the other variables of the consumption function and their source are presented in Table 16.

Production trends for total cereals have been estimated for each country by fitting a logarithmic time trend to actual production data for the period 1960 to 1975. The trend equations obtained are in the form of

(2)

$$\overline{Q}_{it} = \overline{Q}_{io}\, e^{b_i (t-1960)} \qquad t = 1960, 1961, \ldots$$

where $\overline{Q}_{it}$, $\overline{Q}_{io}$ are trend production for the ith country of year t, and the base year 1960, respectively; and b_i is the annual rate of growth of cereal production for the ith country. Annual cereal growth rates and the 1975 trend production levels are presented in Table 17.

The variability of cereal production above and below trend has been analyzed for each country. Actual production levels for each year from 1960 to 1975 have been expressed as a percentage deviation from trend, as

(3)

$$q_{it} = \frac{Q_{it} - \overline{Q}_{it}}{\overline{Q}_{it}} 100$$

where Q_{it} is the actual production level in year t. The standard deviations of this production variability measure are also presented in Table 17.

Production variability of individual countries was correlated with that of other countries within the same geographical region. Countries which showed significant correlation were then grouped together. This re-

Table 16—Parameters used in cereal demand projections

Country	Annual Per Capita GNP Growth Rate (%) [a]	Income Elasticity [b]		Per Capita Trend Consumption (1975) [c] (kg/person)		Population Projections (thousands) [d]		
		Foodgrain	Feedgrain	Foodgrain	Feedgrain	1975	1980	1985
Korea, Rep. of	5.5	.030	1.160	271.7	21.9	33,949	37,444	41,260
Malaysia	2.9	.050	1.070	174.0	8.3	12,093	13,998	16,076
Bangladesh	0.5	.500	1.170	179.8	0.3	73,746	84,803	98,003
India	1.1	.470	1.170	163.0	1.4	613,218	694,309	782,890
Indonesia	3.1	.420	1.170	143.0	1.3	136,044	154,869	175,471
Philippines	1.8	.300	1.080	139.5	19.3	44,436	52,203	60,842
Burma	0.7	.500	...	192.2	0.0	31,240	35,195	39,687
Sri Lanka	1.6	.480	...	151.8	0.0	13,986	15,465	16,992
Algeria	3.0	.250	...	172.6	0.0	16,792	19,828	23,501
Iran	5.8	.080	.950	191.2	35.1	32,923	38,492	44,904
Iraq	3.6	.220	...	255.7	0.0	11,067	13,145	15,578
Libya	3.4	.080	...	274.3	0.0	2,255	2,638	3,086
Egypt, Arab Rep. of	1.1	.160	...	279.1	0.0	37,543	42,144	47,191
Turkey	2.9	.000	.930	317.0	84.8	39,882	45,364	51,692

Table 16—Continued

Country	Annual Per Capita GNP Growth Rate (%) a/	Income Elasticity b/		Per Capita Trend Consumption (1975) c/		Population Projections (thousands) d/		
		Foodgrain	Feedgrain	Foodgrain (kg/person)	Feedgrain (kg/person)	1975	1980	1985
Cyprus	4.0	.000	...	527.5	0.0	673	714	755
Jordan	0.9	.073	1.120	133.8	32.3	2,688	3,177	3,752
Lebanon	2.3	.028	.760	168.9	53.3	2,869	3,360	3,956
Morocco	1.4	.050	...	321.1	0.0	17,504	20,384	23,788
Syrian Arab Rep.	3.0	.050	1.170	255.4	16.5	7,259	8,536	10,081
Tunisia	2.9	.738	1.040	210.9	22.8	5,747	6,562	7,537
Afghanistan	0.5	.250	...	225.3	0.0	19,280	22,038	25,207
Yemen Arab Rep.	0.5	.500	...	99.4	0.0	6,668	7,741	9,000
Sudan	1.3	.500	...	136.5	0.0	18,268	21,420	25,147
Nigeria	6.3	.500	1.130	127.1	0.6	62,925	72,596	84,400
Angola	2.8	.428	...	97.9	0.0	6,353	7,181	8,188
Cameroon	2.3	.400	...	126.6	0.0	6,398	7,088	7,987
Ghana	0.5	.500	...	95.7	0.0	9,873	11,446	13,395
Ivory Coast	2.6	.500	...	160.5	0.0	4,885	5,579	6,399

Table 16–Continued

Country	Annual Per Capita GNP Growth Rate (%) a/	Income Elasticity b/		Per Capita Trend Consumption (1975) c/ (kg/person)		Population Projections (thousands) d/		
		Foodgrain	Feedgrain	Foodgrain	Feedgrain	1975	1980	1985
Liberia	1.6	.500	...	87.0	0.0	1,708	1,937	2,199
Senegal	0.5	.244	.840	235.7	1.1	4,418	4,989	5,642
Zambia	1.7	.100	.970	242.2	8.2	5,022	5,874	6,920
Chad	0.5	.500	...	5.9	0.0	4,023	4,473	4,978
Benin	0.7	.483	...	78.9	0.0	3,074	3,534	4,070
Gambia	2.8	.500	...	68.2	0.0	510	563	624
Guinea	0.5	.483	...	89.5	0.0	4,416	5,014	5,718
Malagasy	0.5	.100	...	199.7	0.0	8,020	9,329	10,909
Malawi	2.9	.089	...	253.9	0.0	4,916	5,577	6,369
Mali	0.9	.350	...	136.2	0.0	5,697	6,470	7,374
Niger	0.5	.200	...	179.9	0.0	4,592	5,272	6,077
Rwanda	0.5	.500	...	66.6	0.0	4,200	4,865	5,654
Sierra Leone	1.2	.500	...	132.6	0.0	2,983	3,392	3,870
Tanzania	2.0	.324	...	162.5	0.0	15,438	18,052	21,142

Table 16—Continued

Country	Annual Per Capita GNP Growth Rate (%) a/	Income Elasticity b/		Per Capita Trend Consumption (1975) c/ (kg/person)		Population Projections (thousands) d/		
		Foodgrain	Feedgrain	Foodgrain	Feedgrain	1975	1980	1985
Uganda	1.4	.274	...	119.3	0.0	11,353	13,222	15,423
Upper Volta	0.5	.291	...	162.4	0.0	6,032	6,774	7,639
Zaire	2.0	.500	...	38.0	0.0	24,485	27,952	32,139
Brazil	3.0	.100	.480	151.5	76.2	109,730	126,389	145,082
Ecuador	3.0	.420	.880	80.0	9.8	7,090	8,303	9,689
Mexico	2.5	.100	.610	225.1	69.3	59,204	69,965	82,803
Venezuela	3.0	.190	.460	137.1	49.9	12,213	14,134	16,326
Bolivia	1.9	.450	.860	104.0	32.0	5,410	6,162	7,013
Chile	1.3	.000	.690	199.6	46.3	10,253	11,235	12,303
Colombia	2.0	.268	.690	77.7	17.3	25,890	30,215	35,050
Paraguay	1.5	.099	...	157.8	0.0	2,647	3,062	3,540
Peru	1.5	.370	.770	125.9	41.1	13,526	17,711	20,424
Costa Rica	2.2	.178	.640	109.7	31.6	1,994	2,286	2,611
Cuba	0.5	.218	...	195.5	0.0	9,481	10,533	11,660

Table 16—Continued

Country	Annual Per Capita GNP Growth Rate (%) a/	Income Elasticity b/		Per Capita Trend Consumption (1975) c/		Population Projections (thousands) d/		
		Foodgrain	Feedgrain	Foodgrain (kg/person)	Feedgrain	1975	1980	1985
Dominican Rep.	2.3	.500	.850	67.0	23.5	5,118	6,052	7,171
El Salvador	1.4	.298	.700	125.6	37.8	4,108	4,813	5,643
Guatemala	2.5	.155	.700	152.5	11.5	6,129	7,100	8,210
Haiti	0.5	.500	...	80.4	0.0	4,552	4,956	5,441
Honduras	1.2	.175	.650	134.5	14.2	3,037	3,595	4,242
Jamaica	2.7	.211	...	144.4	0.0	2,029	2,172	2,316
Nicaragua	2.2	.250	.610	138.2	33.3	2,318	2,732	3,218
Panama	3.1	.180	.700	120.1	21.2	1,678	1,930	2,217
Trinidad	3.0	.037	...	212.6	0.0	1,009	1,062	1,116

a/ A low income growth assumption is made here. These growth rates were arrived at from the 1976 World Bank Atlas and other World Bank materials.

b/ Income elasticities were largely derived from FAO (Agricultural Commodity Projections 1970-1980, Vol. 2, 1971), adjusted to accommodate the low income growth assumption.

c/ Obtained from a logarithmic fit to actual per capita data for the period of 1960 to 1975 provided by the USDA.

d/ United Nations population estimates and medium variant projections are used here.

Table 17—Estimates of cereal production trends and variability from trend by country

Country	Cereal Production [a]		
	Base Year 1960 (thousand metric tons)	Annual Growth Rate (%)	Variability from Trend [b] (%)
Korea, Rep. of	5,046.9	2.083	5.87
Malaysia	615.7	5.433	5.08
Bangladesh	9,587.1	1.496	7.18
India	65,055.8	2.721	6.62
Indonesia	10,238.3	3.863	7.13
Philippines	3,470.1	3.965	6.12
Burma	4,861.0	1.327	7.09
Sri Lanka	623.9	3.327	14.14
Algeria	1,753.2	-0.628	30.32
Iran	4,130.5	2.836	9.87
Iraq	1,745.3	1.370	24.62
Libya	125.9	0.757	29.30
Egypt, Arab Rep. of	5,083.3	2.385	4.58
Turkey	12,055.3	1.979	9.51
Cyprus	127.5	-0.022	41.86
Jordan	158.6	1.053	59.95
Lebanon	85.1	-2.437	25.50
Morocco	2,301.9	4.682	31.14
Syrian Arab Rep.	1,264.2	1.376	42.22
Tunisia	415.8	5.543	33.74
Afghanistan	3,374.1	1.560	7.06
Yemen Arab Rep.	603.1	-0.855	7.59
Sudan	1,345.8	3.873	17.14

Table 17—Continued

Country	Cereal Production [a]		
	Base Year 1960 (thousand metric tons)	Annual Growth Rate (%)	Variability from Trend [b] (%)
Nigeria	7,714.1	-0.023	10.66
Angola	445.6	1.831	12.53
Cameroon	661.4	0.706	14.24
Ghana	358.6	5.148	9.88
Ivory Coast	289.0	4.642	10.79
Liberia	91.8	1.173	15.40
Senegal	527.8	1.953	18.23
Zambia	621.2	4.142	29.34
Chad	18.9	1.612	21.76
Benin	296.4	-1.268	7.20
Gambia	20.3	0.947	16.06
Guinea	230.0	2.706	11.02
Malagasy	998.2	2.502	8.27
Malawi	813.8	2.648	12.84
Mali	1,071.2	-2.285	11.18
Niger	841.9	-0.406	9.91
Rwanda	266.2	0.427	10.91
Sierra Leone	259.3	1.919	5.23
Tanzania	1,801.2	1.669	10.76
Uganda	868.7	3.017	7.54
Upper Volta	852.3	0.623	18.08
Zaire	284.8	5.171	7.94
Brazil	13,731.3	3.756	5.38

Table 17—Continued

Country	Cereal Production [a]		
	Base Year 1960 (thousand metric tons)	Annual Growth Rate (%)	Variability from Trend [b] (%)
Ecuador	381.9	0.964	8.54
Mexico	7,959.5	4.652	9.28
Venezuela	528.6	3.446	13.30
Bolivia	375.0	1.902	5.22
Chile	1,630.9	-0.295	12.44
Colombia	1,310.7	3.049	7.13
Paraguay	147.3	5.935	4.12
Peru	1,003.4	1.888	5.89
Costa Rica	107.7	1.899	8.54
Cuba	208.6	3.197	25.82
Dominican Rep.	117.7	4.399	5.87
El Salvador	275.4	5.200	11.86
Guatemala	589.2	2.858	5.30
Haiti	283.0	0.399	7.66
Honduras	349.3	0.855	9.68
Jamaica	5.6	1.878	34.57
Nicaragua	196.4	3.999	12.61
Panama	149.5	0.816	13.62
Trinidad	8.5	3.354	11.31

a/ The logarithmic trend on total grain production was fitted using data from 1960 to 1975 provided by the USDA.

b/ Measured as the standard deviation of percentage variations of actual production (Q_{it}) from trend production ($\overline{Q}_{it}$), i.e., $(Q_{it}-\overline{Q}_{it}) / \overline{Q}_{it}$ for the period 1960-75.

gional classification of countries according to their degree of correlation in production variability is given in Table 18. Countries whose production did not show a significant positive correlation with any other country within their geographical region were assumed independent.

For the simulation analysis the generation of production levels for each country took into consideration the observed regional correlation in production by jointly generating production deviation vectors. Thus, the percentage deviations of production of the n countries in the jth region were obtained from a multivariate normal distribution, i.e.,

(4)

$$\begin{bmatrix} q_{1t} \\ q_{2t} \\ \cdot \\ \cdot \\ \cdot \\ q_{nt} \end{bmatrix}_j \sim N \left(\begin{bmatrix} 0 \\ 0 \\ \cdot \\ \vdots \\ \cdot \\ 0 \end{bmatrix}, \Sigma_j \right),$$

for all t, where Σ_j is the estimated variance-covariance matrix of observed percentage deviations of the n countries in the jth region. Assume that q^*_{it} is one generated value from the above process for the ith country, corresponding to year t. Then, the corresponding production level is obtained by solving (3) for Q_{it}, i.e.,

(5)

$$Q^*_{it} = \left(1 + \frac{q^*_{it}}{100} \right) \cdot \overline{Q}_{it}$$

where $\overline{Q}_{it}$ is the trend production as obtained from (2).

Production variability as specified above is multiplicative in nature which means that although production deviations from trend expressed as a percentage do not grow over time, the absolute levels of production fluctuations increase with time.

Table 18—Matrix of correlations between percentage deviations from cereal production trend for countries by region

	1	2	3	4	5
South Asia					
1. India	1				
2. Sri Lanka	0.54	1			
Far East Asia					
1. Bangladesh	1				
2. Burma	0.49	1			
3. Indonesia	0	0	1		
4. Philippines	0.52	0.18	0.44	1	
East Africa					
1. Malagasy	1				
2. Malawi	0.73	1			
3. Tanzania	0.15	0.20	1		
4. Uganda	0.51	0.27	0	1	
5. Zambia	0.66	0.69	0.50	0.34	1

Table 18—Continued

	West Africa											
	1	2	3	4	5	6	7	8	9	10	11	12
1. Cameroon	1											
2. Chad	0.29	1										
3. Benin	0.15	0	1									
4. Gambia	0.12	0.48	0	1								
5. Guinea	0.64	0	0.19	0	1							
6. Ivory Coast	0.62	0.53	0.33	0	0.51	1						
7. Liberia	0.11	0	0	0	0	0	1					
8. Mali	0	0.30	0.43	0	0.24	0.58	0	1				
9. Niger	0.35	0.61	0.45	0.21	0	0.62	0	0.67	1			
10. Senegal	0.26	0.27	0.66	0	0	0.50	0.20	0.55	0.54	1		
11. Sierra Leone	0	0	0	0	0	0	0.52	0	0	0	1	
12. Upper Volta	0.60	0.44	0.28	0.23	0	0.45	0.42	0	0.51	0.49	0	1

Table 18–Continued

	North Africa and Near East Asia												
	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Afghanistan	1												
2. Iran	0.39	1											
3. Iraq	0.46	0.32	1										
4. Jordan	0	0	0.17	1									
5. Lebanon	0	0	0.19	0.32	1								
6. Syrian Arab Rep.	0.12	0	0.45	0.45	0.61	1							
7. Yemen Arab Rep.	0	0	0	0.13	0.35	0.21	1						
8. Cyprus	0	0	0.19	0.57	0.34	0.53	0	1					
9. Algeria	0.12	0.13	0.47	0	0	0.37	0	0.24	1				
10. Egypt, Arab Rep. of	0	0.22	0	0	0	0	0	0	0.48	1			
11. Morocco	0	0.45	0.37	0	0	0	0	0.19	0.59	0.69	1		
12. Libya	0.55	0.36	0.47	0.13	0.28	0.45	0	0.16	0.11	0	0	1	
13. Tunisia	0	0.24	0	0	0	0.34	0.59	0	0.42	0.11	0	0	1

Table 18—Continued

Central America

	1	2	3	4	5	6	7	8
1. Costa Rica	1							
2. Cuba	0	1						
3. Guatemala	0	0	0					
4. Jamaica	0.20	0.43	0	1				
5. Mexico	0	0	0.44	0	1			
6. Panama	0.53	0	0.31	0	0.48	1		
7. Nicaragua	0.52	0	0.39	0	0.54	0.78	1	
8. Trinidad	0.21	0.40	0	0.71	0	0	0	1

South America

	1	2	3	4	5	6	7
1. Brazil	1						
2. Chile	0.23	1					
3. Colombia	0.43	0	1				
4. Ecuador	0	0.35	0	1			
5. Paraguay	0.40	0.45	0	0.22	1		
6. Peru	0.18	0.34	0	0.51	0.19	1	
7. Venezuela	0.39	0.71	0	0.49	0.15	0.13	1

Appendix 3

WORLD WHEAT PRICE GENERATION

In order to obtain cereal import expenditures which are the basis for estimating compensations paid to each food deficit developing country, a way of generating world wheat prices is needed.* One approach to this is to analyze past world price distribution and on the basis of this distribution devise a random number generating function which would approximate the observed price data. This approach would be appropriate to use if one were concerned with a single small importing country whose import demand had no practical effect on world price. However, this analysis, dealing as it does with countries that account for more than 40 percent of total world wheat imports, cannot ignore the causal effect of their demand on world price.

Thus, the first attempt to explore this causal relationship is to regress world wheat price on total cereal imports of food deficit developing countries (FDDC) to see whether a relationship exists. Using data from 1960 to 1975, this regression yielded the following equation:

$$P_t = -30.1 + 0.003445 \cdot M_t \text{ , } R^2 = .67 \qquad (5.2)$$

where P_t is the world wheat price, M_t total cereal imports of all FDDC's. Since the coefficient of M_t proves significant, FDDC import demand should enter the price generating function. Obviously, import demand from the rest of the world also has a causal effect on the world price of wheat. This analysis, however, simulates import demand of a subgroup of importers only, and treats the effect on price of the demand by the rest of the world as the random component of the price generating function.

Another factor to be incorporated into the random price generating function is the serial correlation observed in price time series. Very high wheat price in year t—1 is not followed by a very low price in year t, and vice-versa. This is the effect of carryover stocks on prices. Thus, if year t-1 is a poor harvest year worldwide, prices will rise and accumulated stocks will be depleted. If year t is also a poor crop year, depleted stocks will force current prices even higher. If year t is a good crop year, price will drop but not to very low levels, because the additional demand to replace part of depleted stocks keeps price from falling. This reasoning suggests that a lagged price should be included in the price generating function.

Finally, in order to avoid any trend in real price, both imports and world price are introduced as normalized variables and regression on 1960-75 actual data provides the following relationship:

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* The composition of cereal imports varies from country to country depending on consumption preferences and even for the same country from year to year depending on the variability of the composition in its domestic cereal production and changes in taste. The composition of cereal imports will not be of concern in this study. Instead, wheat is taken as the basic staple commodity, and the value of cereal imports is computed as if these imports were composed of wheat.

$$\log_e \frac{P_t}{P^*} = -0.89028 + 0.96268 \frac{M_t}{\overline{M}_t} +$$
$$(2.0)$$
$$0.86181 \log_e \frac{P_{t-1}}{P^*} + u_t$$
$$(4.6)$$

$$SE = 0.17378 \qquad R^2 = 0.75$$

where P_t is world wheat price in year t (in constant 1972 dollars);

P^* is the average world wheat price for the pre-1972 period ($74.1/MT) which is assumed to approximate the cost of production in exporting countries;

M_t, $\overline{M}_t$ are total food deficit developing countries' actual and trend cereal imports, respectively, in year t; and

u_t is the random component of the price generating function in year t.

The log-linear specification used above is meant to reflect the non-linear price behavior ascribed to the international wheat market.

The price generating function used in the simulation was based on the estimated relationship. P^* was adjusted to reflect current production costs in exporting countries. Thus, P^* is set at $85.0 per metric ton (about $2.31 per bushel) which is approximately the current level of the United States government's wheat loan rate and thus reflects current production costs. As an initial value for the lagged price (P_{t-1}), the average wheat price for the last three years (1975-77) is used. This price, a simple average of United States and Canadian wheat prices expressed in 1977 dollars, equals $137.0 per metric ton.

A price outcome is computed from this function after the generation of an import outcome (the difference between total projected cereal demand and total randomly generated cereal production, as described in Appendix 2) and an outcome of the random component u_t. The distribution obtained from 300 five-year production sequences is depicted in Table 19.

The initial value of the lagged price affects somewhat the price distribution. Thus, the distribution of the first year (1978) is not as dispersed as it would have been if the initial price was allowed to take a randomly generated value. This is designated as "first year distribution" in Table 19. The impact of the initial assigned value is considerably less by the second and third years and is practically non-existent thereafter. In other words, from the third year on, the price distribution obtained with an assigned initial value is practically the same as the distribution obtained with an initial price randomly generated. This is designated as "equilibrium distribution" in Table 19. The expected prices obtained are $146.7 per metric ton for 1978, $150.7 per metric ton for 1979, $153.6 per metric ton for 1980, and $155.8 per metric ton for the years thereafter.

Table 19—World wheat price distribution [a/]

Price Interval ($/MT)	First Year Distribution (1978)		Equilibrium Distribution	
	Relative Frequency (%)	Cumulative Frequency (%)	Relative Frequency (%)	Cumulative Frequency (%)
Less than 70	0.67	0.67	1.67	1.67
70–90	5.00	5.67	7.69	9.36
90–110	15.00	20.67	13.05	22.41
110–130	17.33	38.00	16.00	38.41
130–150	17.33	55.33	15.50	53.91
150–170	14.33	69.67	13.93	67.84
170–190	13.33	83.00	9.76	77.60
190–210	7.33	90.33	7.02	84.62
210–230	4.33	94.67	4.74	89.36
230–250	2.00	96.67	3.48	92.84
250–270	2.00	98.67	2.60	95.44
270–290	1.00	99.67	1.36	96.80
290–310	0.33	100.00	0.79	97.57
310–330	0.00	100.00	0.83	98.42
330–350	0.00	100.00	0.52	98.94
Greater than 350	0.00	. . .	1.06	. . .

a/ Obtained by the procedure described in the text. The expected prices for 1978, 1979, 1980 and thereafter are $146.7 per metric ton, $150.7 per metric ton, $153.6 per metric ton and $155.8 per metric ton, respectively.

Appendix 4 SUPPLEMENTARY TABLES

Table 20—Probability distribution of present value of the total cost of the scheme operating as a compensatory financing mechanism for the five-year period 1978 to 1982, excluding India a/

Cost b/ ($ billion)	Relative Frequency (%)	Cumulative Frequency (%)
0–1	26.9	26.9
1–2	20.7	47.6
2–3	13.9	61.5
3–4	8.0	69.5
4–5	5.4	74.9
5–6	3.3	78.2
6–7	3.6	81.8
7–8	3.3	85.1
8–9	2.9	88.0
9–10	1.5	89.5
10–11	2.5	92.0
11–12	1.5	93.5
12–13	0.3	93.8
13–14	1.1	94.9
14–15	0.7	95.6
15–16	0.0	95.6
16–17	0.8	96.4
17–18	0.3	96.7
18–19	0.4	97.1
Greater than 19	2.9	. . .

a/ The excess over 110 percent of trend in each country's cereal import bill is covered by the scheme.

b/ The expected present value of the cost equals $4.096 billion. A discount rate of 8 percent has been assumed here.

Table 21—Probability distribution of the current cost of the scheme operating as a compensatory financing mechanism for the middle year (1980) of the five-year period, excluding India [a]

Cost [b] ($ billion)	Relative Frequency (%)	Cumulative Frequency (%)
0–1	74.5	74.5
1–2	10.6	85.1
2–3	5.1	90.2
3–4	4.7	94.9
4–5	1.8	96.7
5–6	1.1	97.8
6–7	1.1	98.9
7–8	0.4	99.3
Greater than 8	0.7	. . .

a/ The excess over 110 percent of trend in each country's cereal import bill is covered by the scheme.

b/ The expected current cost equals $0.960 billion.

Table 22—Probability distribution of the present value of payments made through the compensatory financing mechanism under alternative grain reserve levels a/

Grain Reserve Levels (million MT)	0 b/		4		8		12		16		20	
Payments c/ ($ billions)	Relative Frequency (%)	Cumulative Frequency (%)	Rel. Freq. (%)	Cum. Freq. (%)	Rel. Freq. (%)	Cum. Freq. (%)	Rel. Freq. (%)	Cum. Freq. (%)	Rel. Freq. (%)	Cum. Freq. (%)	Rel. Freq. (%)	Cum. Freq. (%)
0–1	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
1–2	21.8	41.8	21.7	41.7	21.5	41.5	21.1	41.1	22.2	42.2	22.5	42.5
2–3	12.0	53.8	13.4	55.1	16.3	57.8	17.1	58.2	17.1	59.3	16.8	59.3
3–4	7.7	61.5	9.7	64.8	10.6	68.4	10.2	68.4	10.2	69.5	10.5	69.8
4–5	8.0	69.5	7.7	72.5	8.0	76.4	10.1	78.5	10.5	80.0	10.6	80.4
5–6	5.0	74.5	5.5	78.0	4.7	81.1	4.0	82.5	4.7	84.7	5.4	85.8
6–7	4.8	79.3	3.3	81.3	2.2	83.3	2.2	84.7	2.6	87.3	1.5	87.3
7–8	2.2	81.5	2.3	83.6	2.2	85.5	3.3	88.0	2.2	89.5	1.8	89.1
8–9	2.1	83.6	2.4	86.0	2.9	88.4	1.5	89.5	1.4	90.9	2.5	91.6
9–10	3.3	86.9	2.4	88.4	1.4	89.8	1.0	90.5	1.5	92.4	1.1	92.7
10–11	1.5	88.4	1.7	90.1	1.5	81.3	1.5	92.0	1.1	93.5	0.8	93.5
11–12	1.4	89.8	1.1	91.1	1.0	92.3	0.7	92.7	0.7	94.2	1.4	94.9
12–13	1.5	91.3	1.3	92.4	0.8	93.1	0.8	93.5	1.1	95.3	1.1	96.0

Table 22—Continued

Grain Reserve Levels (million MT)	0 [b]		4		8		12		16		20	
Payments [c] ($ billions)	Relative Frequency (%)	Cumulative Frequency (%)	Rel. Freq. (%)	Cum. Freq. (%)	Rel. Freq. (%)	Cum. Freq. (%)	Rel. Freq. (%)	Cum. Freq. (%)	Rel. Freq. (%)	Cum. Freq. (%)	Rel. Freq. (%)	Cum. Freq. (%)
13–14	1.4	92.7	1.2	93.6	1.1	94.2	0.7	94.2	1.1	96.4	0.4	96.4
14–15	0.4	93.1	0.4	94.0	0.9	94.9	1.4	95.6	0.3	96.7	0.3	96.7
15–16	1.1	94.2	1.1	95.1	1.1	96.0	0.4	96.0	0.0	96.7	0.0	96.7
16–17	1.1	95.3	0.9	96.0	0.4	96.4	0.4	97.4	0.4	97.1	0.4	97.1
17–18	1.1	96.4	0.4	96.4	0.0	96.4	0.7	97.1	0.4	97.5	0.4	97.5
Greater than 18	3.6	...	3.6	...	3.6	...	2.9	...	2.5	...	2.5	...
Expected Present Value of Total Payments ($ billion)	5.108		4.789		4.509		4.290		4.124		4.006	

a/ The current cereal import bill in excess of 110 percent of trend is covered for each country.

b/ This corresponds to a system operating as a compensatory financing mechanism only.

c/ In computing present values a discount rate of 8 percent has been assumed.

Table 23—Probability distribution of current payments made for the middle year (1980) of the five-year period under alternative grain reserve levels a/

Grain Reserve Levels (million MT)	0 b/		4		8		12		16		20	
Payments c/ ($ billions)	Relative Frequency (%)	Cumulative Frequency (%)	Rel. Freq. (%)	Cum. Freq. (%)	Rel. Freq. (%)	Cum. Freq. (%)	Rel. Freq. (%)	Cum. Freq. (%)	Rel. Freq. (%)	Cum. Freq. (%)	Rel. Freq. (%)	Cum. Freq. (%)
0–1	69.5	69.5	69.5	69.5	70.9	70.9	71.6	71.6	72.4	72.4	72.4	72.4
1–2	11.6	81.1	12.7	82.2	13.5	84.4	13.1	84.7	13.1	85.5	13.1	85.5
2–3	6.2	87.3	6.9	89.1	6.5	90.9	6.9	91.6	8.4	93.9	8.7	94.2
3–4	4.4	91.7	4.4	93.5	2.6	93.5	4.0	95.6	2.6	96.5	2.2	96.4
4–5	3.6	95.3	1.8	95.3	2.9	96.4	1.5	97.1	1.1	97.6	1.5	97.9
5–6	1.1	96.4	1.8	97.1	1.5	97.9	0.7	97.8	0.4	98.0	0.4	98.3
6–7	1.1	97.5	1.1	98.2	0.4	98.3	0.4	98.3	0.4	98.4	0.7	99.0
7–8	0.7	98.2	0.0	98.2	0.0	98.3	0.0	98.3	0.7	99.1	0.4	99.4
8–9	0.0	98.2	0.0	98.2	0.0	98.3	0.7	99.4	0.4	99.4	0.0	99.4
9–10	0.4	98.6	0.4	98.6	0.4	98.7	0.0	99.4	0.0	99.4	0.0	99.4
10–11	0.7	99.3	0.7	99.3	0.7	99.4	0.4	99.8	0.4	99.8	0.4	99.8
11–12	0.0	99.3	0.0	99.3	0.0	99.4	0.0	99.8	0.0	99.8	0.0	99.8
Greater than 12	0.7	...	0.7	...	0.6	...	0.2	...	0.2	...	0.2	...
Expected Payment ($ billion)	1.229		1.158		1.084		1.012		0.951		0.916	

a/ The excess over 110 percent of trend in each country's current cereal import bill is covered.

b/ This corresponds to a system operating as a compensatory financing mechanism only.

c/ In computing present values a discount rate of 8 percent has been assumed.

Table 24—Probability distribution of the present value of payments made through the compensatory financing mechanism under alternative insurance levels

	Scheme Operating as a Compensatory Financing Mechanism Only						Scheme Operating as a Combination of a Compensatory Financing Mechanism and 20 MT of Grain Reserve					
	Uninsured Import Bill Level						Uninsured Import Bill Level					
	110 Percent [b]		120 Percent		130 Percent		110 Percent		120 Percent		130 Percent	
Payments [a]	Relative Frequency	Cumulative Frequency	Rel. Freq.	Cum. Freq.	Rel. Freq.	Cum. Freq.	Rel. Freq.	Cum. Freq.	Rel. Freq.	Cum. Freq.	Rel. Freq.	Cum. Freq.
($ billions)						(percent)						
0–1	20.0	20.0	25.5	25.5	31.6	31.6	20.0	20.0	25.5	25.5	36.4	36.4
1–2	21.8	41.8	19.6	45.1	23.3	54.9	22.5	42.5	27.3	52.8	30.2	66.5
2–3	12.0	53.8	14.2	59.3	12.4	67.3	16.8	59.3	17.8	70.6	16.4	82.9
3–4	7.7	61.5	9.8	69.1	8.4	75.6	10.5	69.8	12.7	83.3	3.3	86.2
4–5	8.0	69.5	6.5	75.6	5.5	81.1	10.6	80.4	2.9	86.2	4.7	90.9
5–6	5.0	74.5	4.4	80.0	2.2	83.3	5.4	85.8	2.2	88.4	0.7	91.6
6–7	4.8	79.3	1.8	81.8	4.7	88.0	1.5	87.3	2.5	90.9	1.8	93.5
7–8	2.2	81.5	3.6	85.4	0.7	88.7	1.8	89.1	1.5	92.4	1.8	95.3
8–9	2.1	83.6	2.2	87.6	1.8	90.5	2.5	91.6	0.7	93.1	0.4	95.6
9–10	3.3	86.9	1.1	88.7	1.5	92.0	1.1	92.7	1.8	94.9	0.7	96.4
10–11	1.5	88.4	1.8	90.5	1.1	93.1	0.8	93.5	1.1	96.0	0.0	96.4

Table 24—Continued

Payments [a]	Scheme Operating as a Compensatory Financing Mechanism Only						Scheme Operating as a Combination of a Compensatory Financing Mechanism and 20 MT of Grain Reserve					
	Uninsured Import Bill Level						Uninsured Import Bill Level					
	110 Percent [b]		120 Percent		130 Percent		110 Percent		120 Percent		130 Percent	
	Relative Frequency	Cumulative Frequency	Rel. Freq.	Cum. Freq.	Rel. Freq.	Cum. Freq.	Rel. Freq.	Cum. Freq.	Rel. Freq.	Cum. Freq.	Rel. Freq.	Cum. Freq.
($ billions)						(percent)						
11–12	1.4	89.8	1.1	91.6	1.1	94.2	1.4	94.9	0.0	96.0	0.7	97.1
12–13	1.5	91.3	1.1	92.7	1.5	95.6	1.1	96.0	0.4	96.4	0.4	97.5
13–14	1.4	92.7	1.1	93.8	0.4	96.0	0.4	96.4	0.4	96.8	0.0	97.5
14–15	0.4	93.1	2.2	96.0	0.4	96.4	0.3	96.7	0.7	97.5	0.0	97.5
15–16	1.1	94.2	0.0	96.0	0.0	96.4	0.0	96.7	0.0	97.5	0.0	97.5
16–17	1.1	95.3	0.4	96.4	1.1	97.5	0.4	97.1	0.0	97.5	0.4	97.9
17–18	1.1	96.4	0.0	96.4	0.0	97.5	0.4	97.5	0.0	97.5	0.4	98.3
Greater than 18	3.6	...	3.6	...	2.5	...	2.5	...	2.5	...	1.7	...
Expected Present Value of Total Payments ($ billion)	5.108		4.348		3.690		4.006		3.247		2.603	

a/ In computing present values, a discount rate of 8 percent has been assumed.

b/ The figures under this alternative have been duplicated from Table 22 for comparison.

Table 25—Probability distribution of present value of payments made through the compensatory financing mechanism operating in conjunction with a 20 million metric ton grain reserve, under alternative grain release rules [a/]

	Release Rules					
	Price Greater than $200/MT Shortfall Greater than 5% [c/]		Price Greater than $170/MT Shortfall Greater than 5%		Price Greater than $200/MT Shortfall Greater than 3%	
Payments [b/]	Relative Frequency	Cumulative Frequency	Rel. Freq.	Cum. Freq.	Rel. Freq.	Cum. Freq.
($ billion)			(percent)			
0–1	20.0	20.0	28.0	28.0	21.1	21.1
1–2	22.5	42.5	29.5	57.5	25.1	46.2
2–3	16.8	59.3	13.5	70.9	17.1	63.3
3–4	10.5	69.8	8.0	78.9	10.2	73.5
4–5	10.6	80.4	4.7	83.6	9.1	82.5
5–6	5.4	85.8	1.8	85.5	3.6	86.2
6–7	1.5	87.3	2.9	88.4	2.9	89.1
7–8	1.8	89.1	1.1	89.5	0.7	89.8
8–9	2.5	91.6	2.2	91.6	1.8	91.6
9–10	1.1	92.7	1.1	92.7	1.5	93.1
10–11	0.8	93.5	0.7	93.5	0.7	93.8

Table 25—Continued

Payments b/	Release Rules					
	Price Greater than $200/MT Shortfall Greater than 5% c/		Price Greater than $170/MT Shortfall Greater than 5%		Price Greater than $200/MT Shortfall Greater than 3%	
	Relative Frequency	Cumulative Frequency	Rel. Freq.	Cum. Freq.	Rel. Freq.	Cum. Freq.
($ billion)			(percent)			
11–12	1.4	94.9	0.7	94.2	0.7	94.5
12–13	1.1	96.0	1.5	95.6	1.1	95.6
13–14	0.4	96.4	0.7	96.4	0.7	96:4
14–15	0.3	86.7	0.0	96.4	0.0	96.4
15–16	0.0	96.7	0.0	96.4	0.0	96.4
16–17	0.4	97.1	0.7	97.1	0.7	97.1
17–18	0.4	97.5	0.4	97.5	0.4	97.5
Greater than 18	2.5	...	2.5	...	2.5	...
Expected Present Value of Total Payments ($ billion)	4.006		3.548		3.874	

a/ The excess over 110 percent of trend in each country's current import bill is covered.

b/ In computing present values, a discount rate of 8 percent has been assumed.

c/ This column has been duplicated from Table 22 for comparison.

Appendix 5

COUNTRY LIST

A. Developing Countries with Foreign Exchange

1. Asia Group
   a. Malaysia
   b. Republic of Korea

2. North Africa/Middle East (OPEC Group)
   a. Algeria
   b. Iran
   c. Iraq
   d. Libya

3. Latin America: Venezuela

B. Developing Countries with Foreign Exchange Constraints

1. Asia Market Economies
   a. Bangladesh
   b. Burma
   c. India
   d. Indonesia
   e. The Philippines
   f. Sri Lanka

2. North Africa/Middle East (Non-OPEC)
   a. Middle Income
      (1) Morocco
      (2) Turkey
      (3) Other Middle-Income: Cyprus, Jordan, Lebanon, Syria, Tunisia
   b. Low Income
      (1) Afghanistan
      (2) Egypt
      (3) Sudan
      (4) Yemen Arab Republic

3. Sub-Sahara Africa

West

a. Middle Income

(1) Ghana
(2) Other Middle Income: Angola, Ivory Coast, Liberia

b. Low Income

(1) Nigeria
(2) Sahel Countries: Chad, Mali, Niger, Senegal, Upper Volta
(3) Other Low Income: Benin, Cameroon, Gambia, Guinea, Sierra Leone

East

a. Middle Income: Zambia

b. Low Income

(1) Tanzania
(2) Uganda
(3) Zaire
(4) Other Low Income: Malagasy, Malawi, Rwanda

4. Latin America

a. Middle Income

(1) Brazil
(2) Chile
(3) Colombia
(4) Ecuador
(5) Mexico
(6) Peru
(7) Other Latin America: Costa Rica, Cuba, Dominican Republic, El Salvador, Guatemala, Honduras, Jamaica, Nicaragua, Panama, Paraguay, Trinidad

b. Low Income: Bolivia, Haiti

The sixty-five countries are grouped according to the categories established for IFPRI's Research Report No. 3, Food Needs of Developing Countries: Projections of Production and Consumption to 1990. They are grouped by income based on the average 1973 GNP per capita: middle income, US$ 300 or more; and low income, less than US$ 300. Asian countries all fall under the low income group.

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